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YELLOWSTONE GRIZZLY BEAR INVESTIGATIONS

ANNUAL REPORT OF THE INTERAGENCY STUDY TEAM

1980

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National Park Service
U.S. Forest Service
Montana Fish and Game Department
U.S. Fish and Wildlife Service
Idaho Fish and Game Department
Wyoming Game and Fish Department

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INTRODUCTION

The Interagency Grizzly Bear Study Team, initiated in 1973, is a cooperative effort of the National Park Service, Fish and Wildlife Service, Forest Service, and since 1974 the States of Wyoming, Montana, and Idaho. This research provides immediate and long range information needed by various management agencies on the grizzly bears *(Ursus arctos horribilis)* that inhabit the Yellowstone system. With increasing demands on most resources in the area, it is apparent that current quantitative data on grizzly bears is urgently required for management decisions.

Earlier research on grizzlies within Yellowstone National Park provided data for the period 1959-67 (Craighead et al. 1974). However, changes in management operations by the Park Service since 1967 - mainly the closing of open pit garbage dumps - have markedly changed some habitat and population parameters (Meagher and Phillips 1980). Thus, current research efforts are needed to define and evaluate grizzly bear population dynamics. Objectives of the study are to determine the status and trend of the grizzly bear population, the use of habitats and food items by the bears, and the effects of land management practices on the bear population.

Distribution of grizzly bears within the study area, movement patterns, and habitat use have been largely determined and are now being studied on a monitoring and updating level. Efforts are being concentrated on gathering population data, determining behavior patterns, and assessing the effects of land use practices adjacent to the park boundary.

Movement data conclusively indicates that the existence of semi-autonomous population segments is unlikely and that the determination of population size will be difficult due to the average home range sizes of individual bears. Population trend indices appear to be more meaningful and measurable than a number estimate.

Major objectives for 1980 were as follows:

1. Instrument and monitor female bears and young in order to obtain estimates of reproductive rates, cub and yearling survival rates, recruitment, and dispersal.
2. Emphasize collection of data on early spring and late fall habitat use and food habits in order to fill in gaps where the data base is weak.

An annotated list of major and minor objectives is given in the 1980 Work Plan (Appendix A).

This study is funded by the National Park Service, the U. S. Fish and Wildlife Service, and the State of Wyoming. Cooperating agencies include Yellowstone National Park, the U. S. Forest Service, and the State wildlife departments of Idaho and Montana. The assistance of many Interagency

Grizzly Bear Study (IGBS) seasonal technicians and pilots, Dave and Roger Stradley, is gratefully acknowledged, as are the Forest Service district personnel and Yellowstone Park in providing field facilities.

MOVEMENTS AND DISTRIBUTION

PROCEDURES

Grizzly bear movements were determined by radio telemetry techniques. Bears were trapped in culvert traps and Aldrich foot snares, fitted with radio transmitters, and released. Telonics transmitters were attached to neck collars which were constructed with two-ply conveyor belting and uralane plastic.

Radio-tracking flights were made approximately twice a week. Types of antennas and tracking techniques were described by Knight et al. (1978). Aerial locations of radio-collared bears were plotted on U. S. Geological Survey topographical maps to within a 100-m^2 plot using the Universal Transverse Mercator system.

Observations of unmarked bears were obtained during aerial flights, ground reconnaissance, and from verified reports.

Previous evaluation of several methods traditionally used to determine home range sizes indicated that the minimum area method (Stickel 1954) gave the best representation of a grizzly bear's range size, shape, and habitat preferences (Knight et al. 1978). A biological center of activity (bio-center) is defined as a clumping of radio locations resulting from intensive use of a relatively small area (Ables 1969). Bio-centers were identified by the length of time spent within the area (minimum 7 days) and/or the number of return visits to that area (minimum four returns). Excursions are sudden, apparently straight line exit and return movements outside a bear's normal range during a short time period.

RESULTS

Movements

Since 1975, 61 grizzly bears have been fitted with radio collars and monitored for varying lengths of time (Fig. 1). During 1980, 28 different grizzlies were captured 32 times, including 13 adults, 8 subadults, 6 yearlings, and 1 cub (Table 1).

Grizzlies were captured at 14 trap locations throughout the study area (Fig. 2). Thirteen bears were captured at 10 different locations within Yellowstone Park, 13 bears at two locations in Montana, and four bears at two locations in Wyoming.

Thirty-four bears were monitored during 1980 compared to 23 and 22 during 1978 and 1979, respectively. Due to the increased number of bears monitored and their wide distribution over the study area, each bear was located fewer times than during previous years. Each bear was located an average of once every 11 days in 1980, compared to once every 7 and 8 days during 1978 and 1979, respectively. The 1980 range use areas

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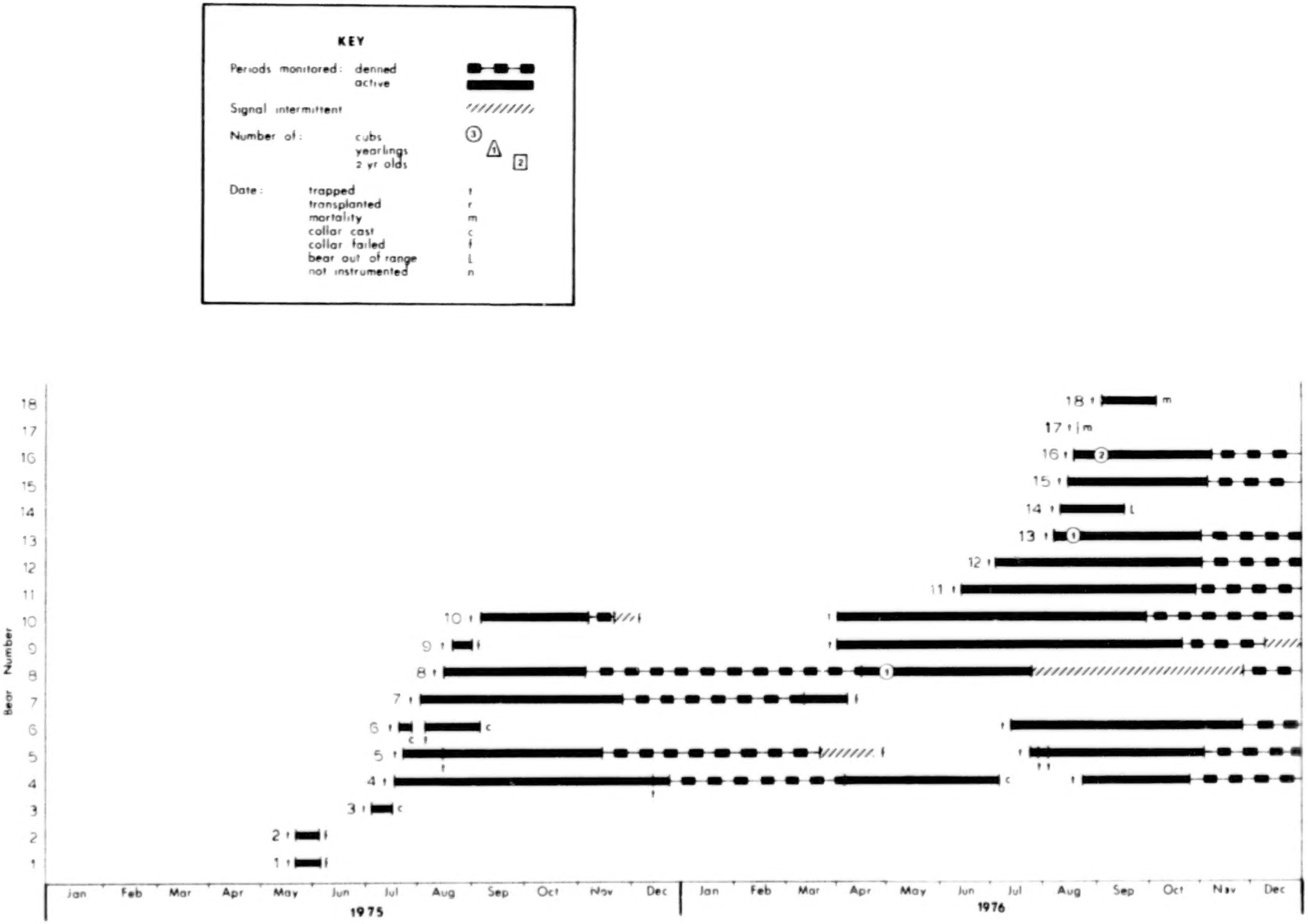

Fig. 1. Histories of radio-collared grizzly bears, 1975-80.

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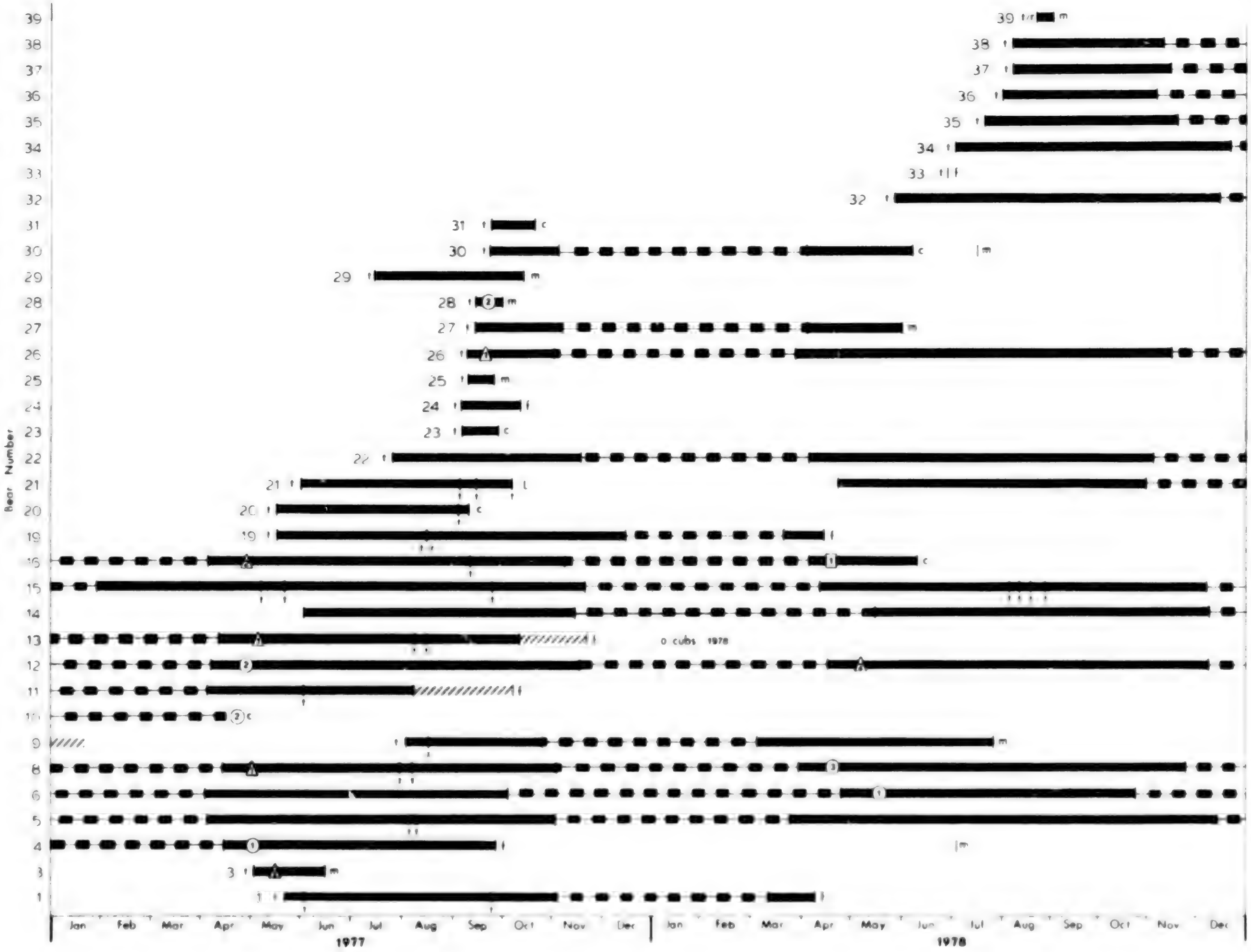

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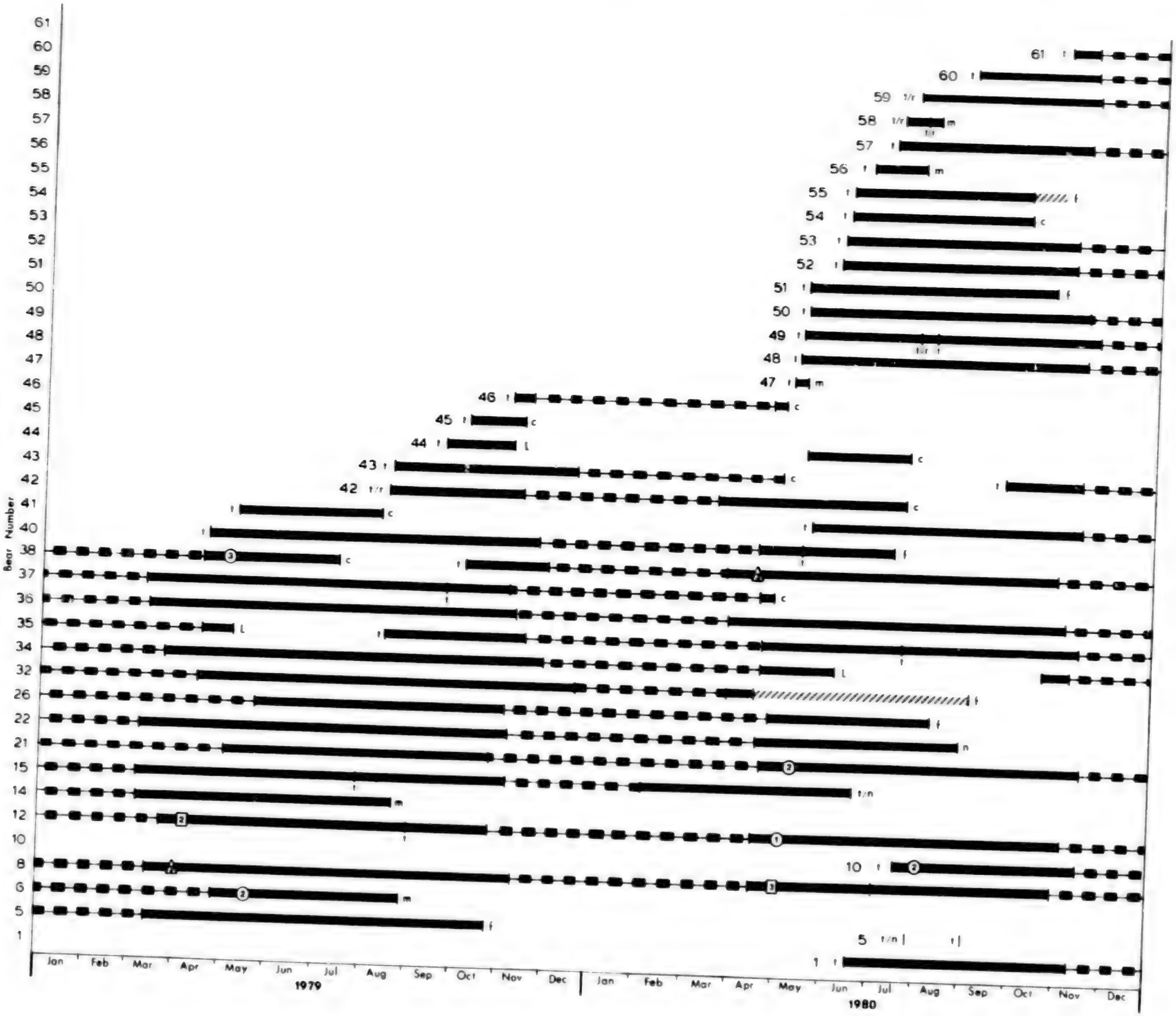

Fig. 1. (continued)

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Table 1. Grizzly bears captured and instrumented during 1980

Bear No.	Sex	Age[1/]	Date	Location	Wt[2/]
47	F	2	05-06 (I)[3/]	Nez Perce Cr, YNP	145
48	F	2	05-10 (I)	Crystal Cr, YNP	225
49	M	2	05-13 (I)	Crystal Cr, YNP	225
49	M	2	07-26 (RIL)	West Entrance, YNP	220
49	M	2	08-08 (RT)	Plateau Cr, YNP	250
50	F	Ad	05-15 (I)	Nez Perce Cr, YNP	275
51	M	13	05-15 (I)	Blacktail Cr, YNP	550
52	M	1	06-05 (I)	Fir Ridge, MT	130
53	F	1	06-06 (I)	Fir Ridge, MT	110
54	M	1	06-10 (I)	Fir Ridge, MT	120
55	M	1	06-11 (I)	Fir Ridge, MT	170*
56	F	1	06-24 (I)	Fir Ridge, MT	150*
57	M	9	07-10 (I)	Cap & Ball Park, WY	600
58	M	2	07-12 (IL)	Norris, YNP	250
59	F	2	07-24 (IL)	Canyon, YNP	175
60	F	3	08-27 (I)	Woody Cr, MT	170*
60	F	3	08-31 (RT)	Woody Cr, MT	180
61	M	4	10-24 (I)	Crandall Cr, WY	535
40	M	5	05-15 (RT)	Rabbit Cr, YNP	400
38	F	9	06-12 (RI)	Fir Ridge, MT	400
41	M	2	05-22 (RI)	Blacktail Cr, YNP	200
43	F	3	09-25 (RI)	Cap & Ball Park, WY	265*
1	M	16	07-28 (RI)	Cap & Ball Park, WY	430*
5	M	12	07-22 (RT)	Woody Cr, MT	390
5	M	12	09-03 (RT)	Woody Cr, MT	450
8	F	14	07-07 (RI)	Woody Cr, MT	230
10	F	9	07-18 (RI)	Woody Cr, MT	310
15	M	9	06-18 (RT)	Fir Ridge, MT	350
22	M	8	08-25 (RT)	Frost Lake, YNP	385
35	M	5	06-19 (RI)	Fir Ridge, MT	325
G-11	F	Cub	07-18 (NI)	Woody Cr, MT	35
G-10	M	2	05-09 (NI)	Crystal Cr, YNP	275

[1/] Ad = adult, males over 4 years old and females over 5 years old.

[2/] Weight in pounds; * indicates scale weight.

[3/] I = Instrumented with transmitter
NI = Not instrumented
RI = Reinstrumented
RT = Retrapped, not reinstrumented
IL = Instrumented and transplanted
RIL = Reinstrumented and transplanted

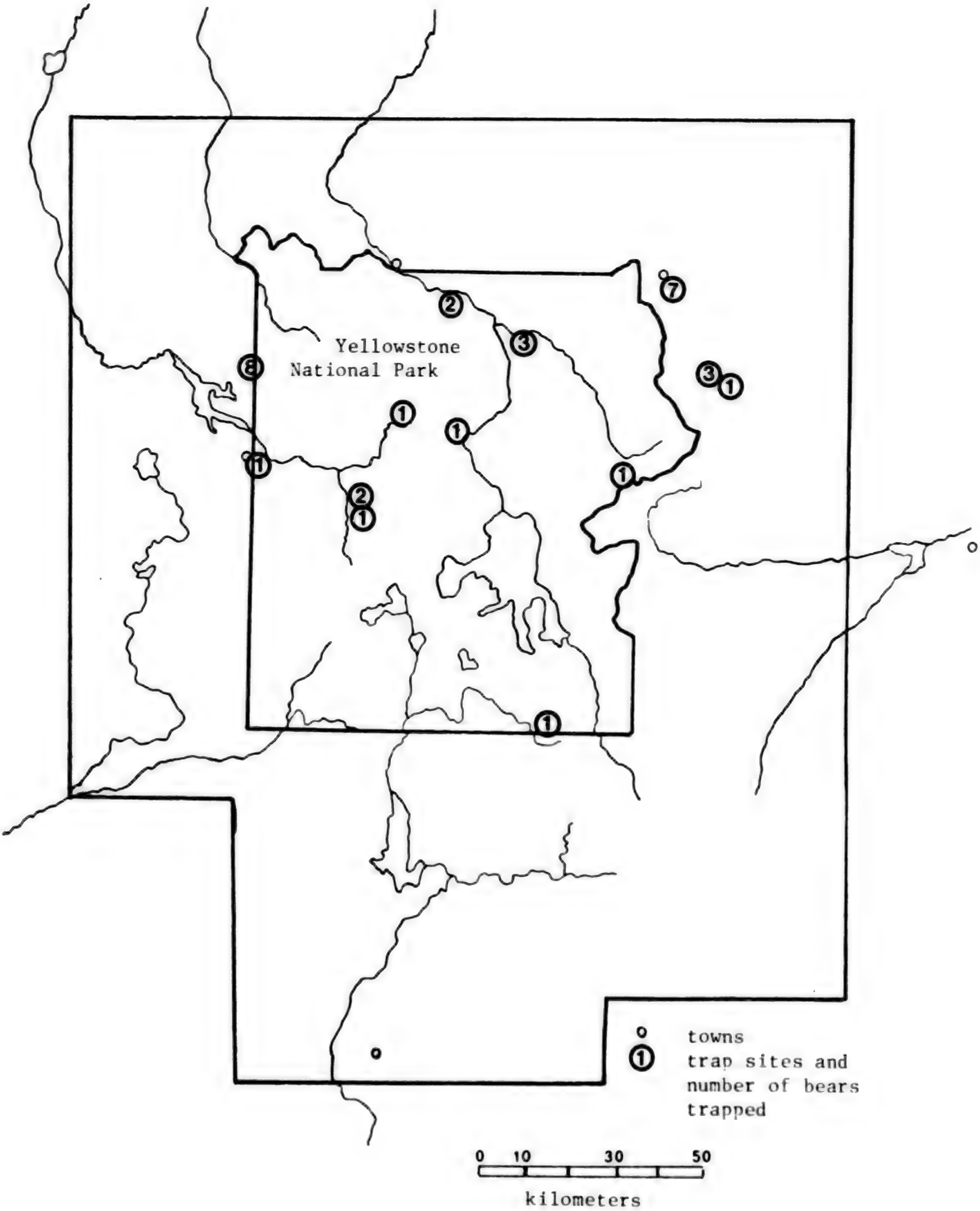
Yellowstone National Park
8
2
3
7
3
1
1
1
1
2
1
1
1
towns
trap sites and number of bears trapped
0
10
30
50
kilometers

Fig. 2. Study area boundaries and 1980 trap sites.

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reflected this reduced sampling intensity and, in most cases, did not accurately depict a bear's range shape and size.

Fourteen of the 34 monitored grizzly bears ceased providing data during the year. Three grizzlies died, five cast their collars, four transmitters apparently failed, and two adult males were released without replacement transmitters.

Minimum range use sizes were calculated for 20 bears in 1980 (Table 2). Range sizes ranged from 7.5 mi^2 to 240.7 mi^2, with an average of 82.3 mi^2 for 10 males and 42 mi^2 for nine females. Range use areas for five adult female, seven adult male, and three subadult female grizzly bears are shown in Figures 3, 4, and 5. Subadult male grizzlies exhibited wider ranging movements and longer excursions than other sex and age classes (Fig. 6).

Forty biological centers of activity were determined for 23 bears. Bio-centers associated with dens were not included. An average bio-center was 2.6 mi^2 in which a bear spent 21 days, left, and returned once.

As usual, grizzly bears did not recognize political boundaries. Individual bears monitored for at least 120 consecutive days and located a minimum of 12 times during that period crossed Forest Service/Park Service boundaries an average of four times (n = 18). Six of these bears did not move outside Park boundaries. The remaining 12 crossed boundaries a minimum of two to 10 times (average = 6).

Distribution

The 1980 distribution of verified observations of unmarked grizzly bears (Fig. 7) did not differ significantly from the distribution of sightings from 1973 through 1979 (Basile, in press). Seventy-four of the 196 observations of unmarked grizzlies were made aerially during 71 radio-tracking and six observation flights. One unmarked grizzly was observed for 4.6 hours of flight time. Grizzly bears were most frequently observed from the air during May and July (Table 3).

Nine observations of grizzly bears outside the study area were reported during 1980. Two verified sightings of lone grizzlies were reported from the Sawtooth Mountains, east of Obsidian, Idaho. Four verified observations of a female with young and one sighting of a large lone grizzly were reported in the vicinity of Buffalo Bill Reservoir, Wyoming. Two nonverified sightings of lone collared grizzly bears were reported: One in Strawberry Creek, southeast of Livingston, Montana; and one in the Wise River drainage, Idaho.

Table 2. Minimum annual use range for instrumented grizzly bears during 1980

Bear No.	Sex	Age[1]	Range (mi^2)	No. of locations	Interval (days)
1	M	16	-	12	157
8	F	14	45	36	366
10	F	9	-	19	167
12	F	12	30	31	366
15	M	9	-	13	170
21	F	7	52	31	319
22	M	8	79	17	125
26	F	16	31	24	220
32	M	4	-	8	246
34	M	8	88	14	366
35	M	5	93	26	254
36	M	12	241	23	310
38	F	9	44	42	366
40	M	5	71	17	193
41	M	2	-	23	224
42	M	9	-	19	208
43	F	3	-	10	255
44	M	Ad	-	11	73
45	M	1	-	2	24
46	M	SAd	-	9	136
48	F	2	75	24	236
49	M	2	55	27	233
50	F	Ad	59	26	231
51	M	13	48	21	163
52	M	1	114	23	210
53	F	1	27	21	209
54	M	1	8	14	120
55	M	1	8	14	115
56	F	1	-	8	45
57	M	9	27	16	175
58	M	2	-	5	23
59	F	2	16	19	120
60	F	3	-	16	127
61	M	4	-	2	69

[1] SAd = subadult; female 2-5 years old, male 2-4 years old.
AD = adult; males over 4 years old, females over 5 years old.

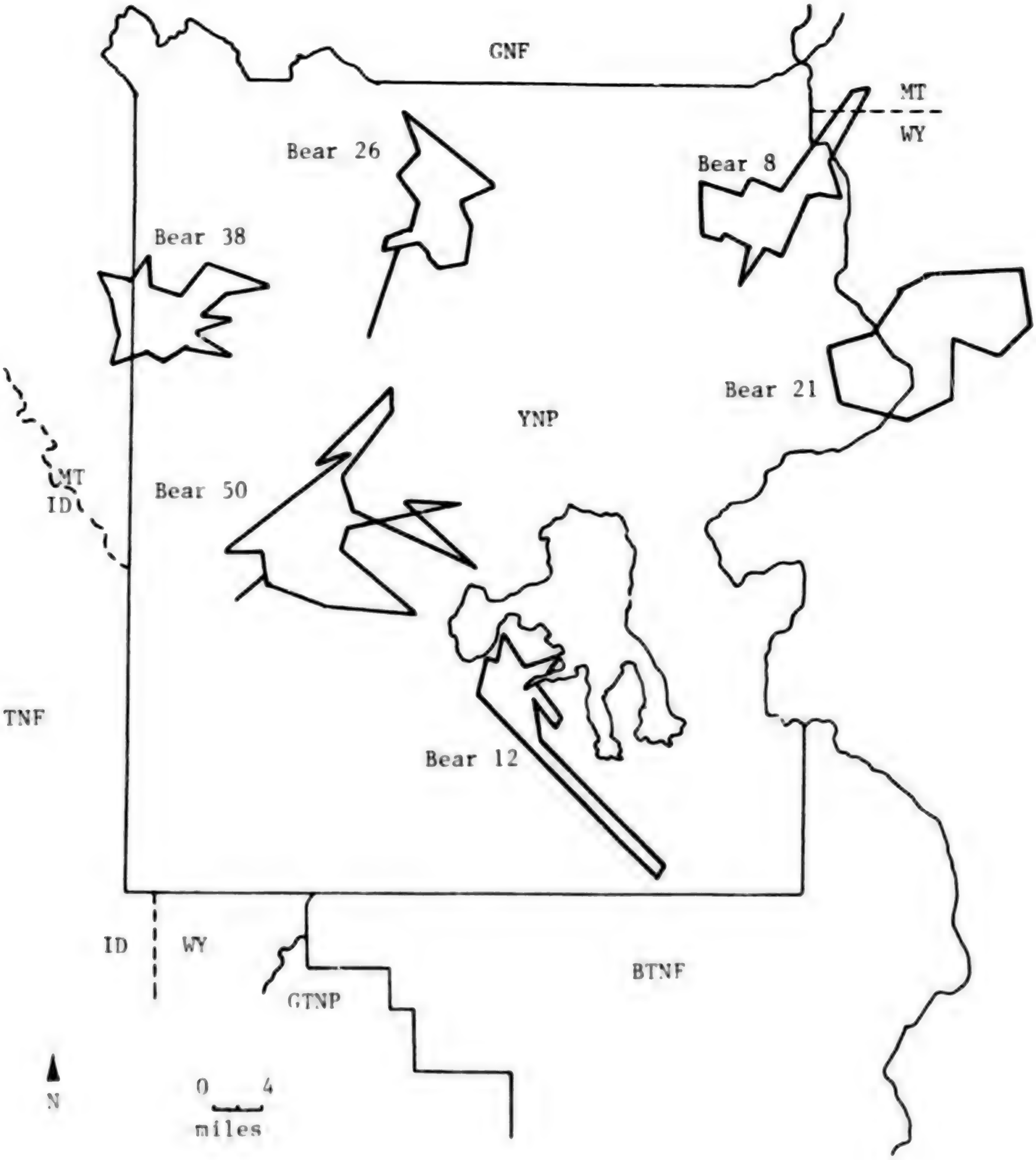

Fig. 3. Range use areas of five adult female grizzly bears during 1980.

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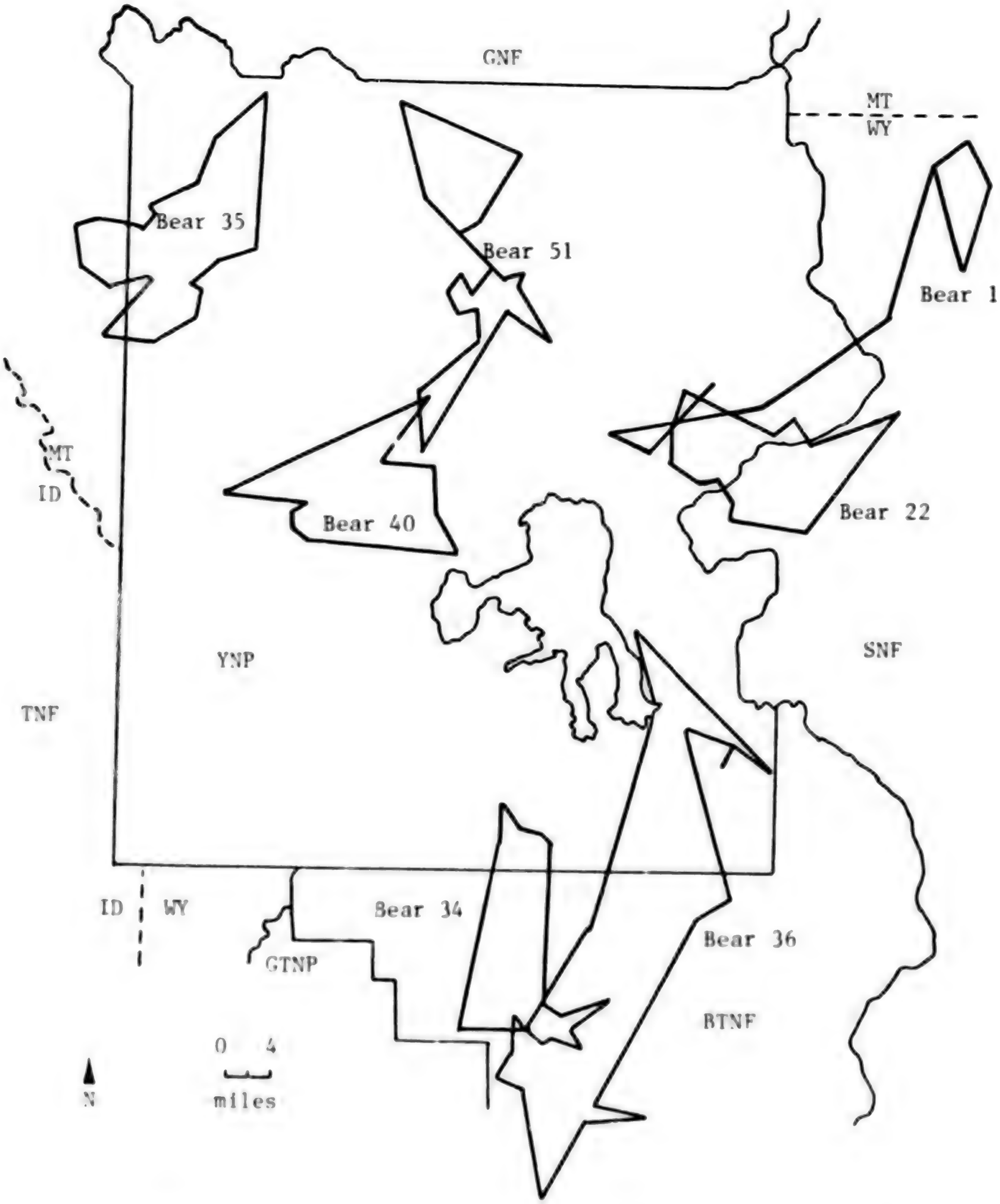

Fig. 4. Range use areas of seven adult male grizzly bears during 1980.

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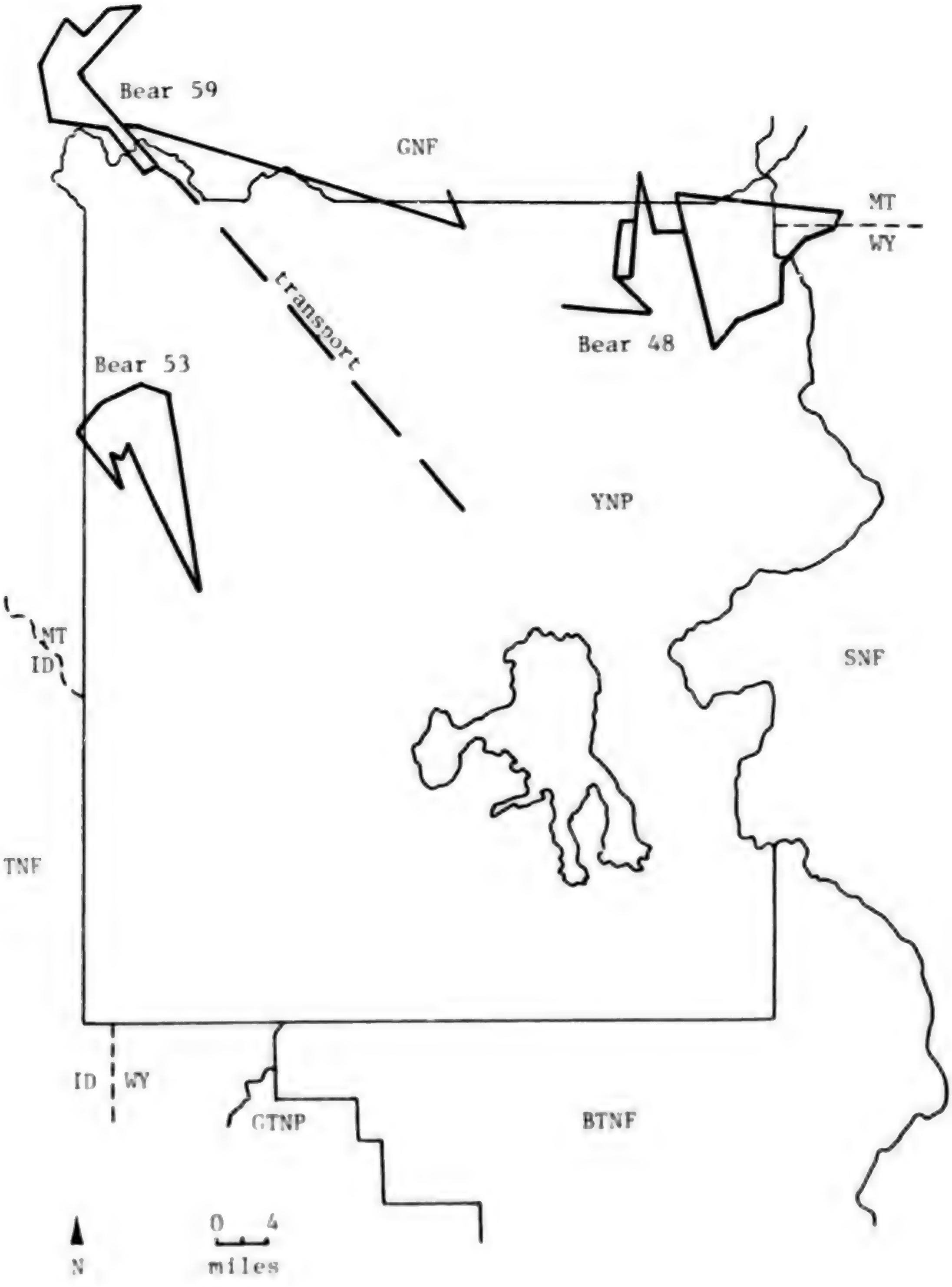

Fig. 5. Range use areas of three subadult female grizzly bears during 1980.

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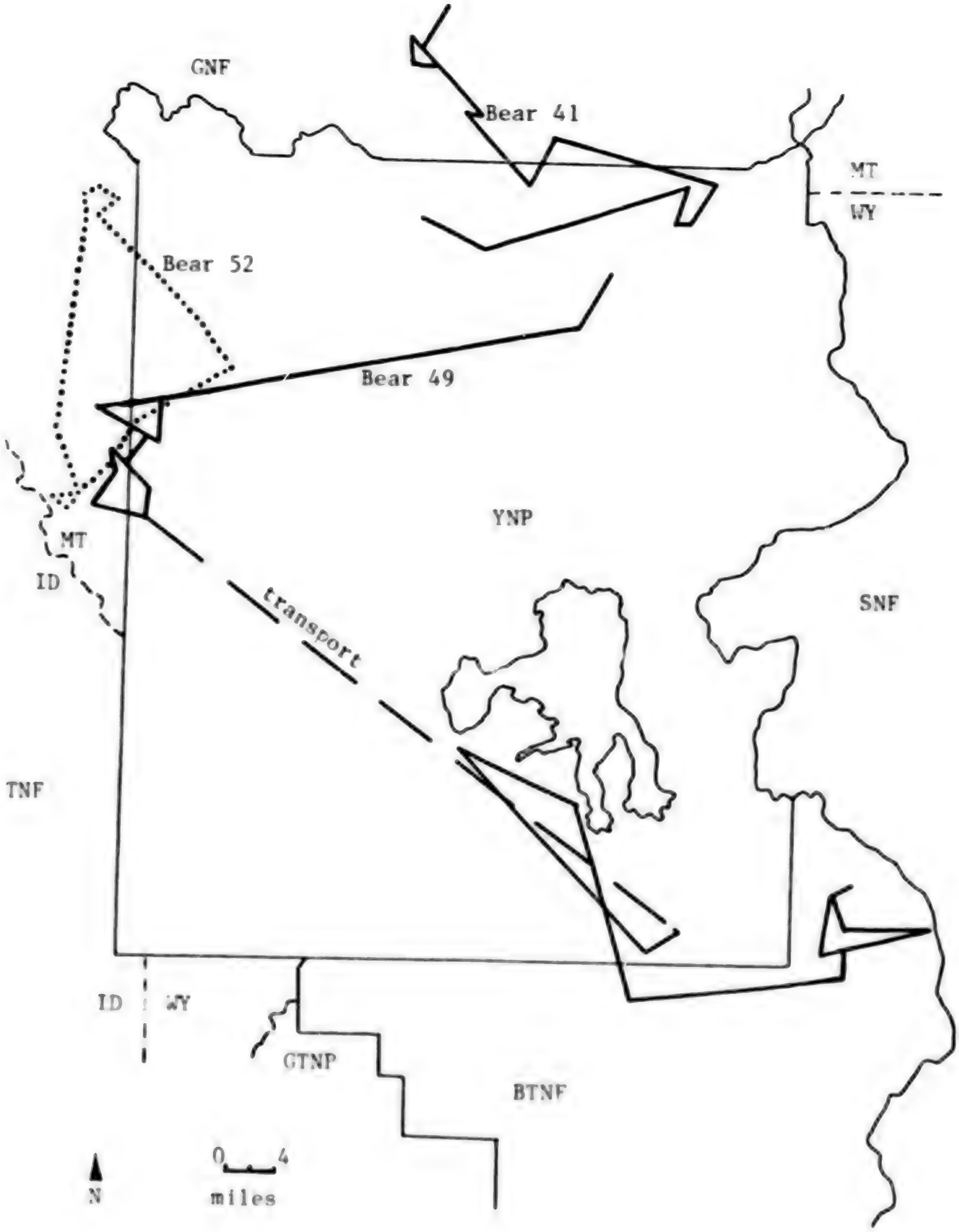

Fig. 6. Range use areas of three subadult male grizzly bears during 1980.

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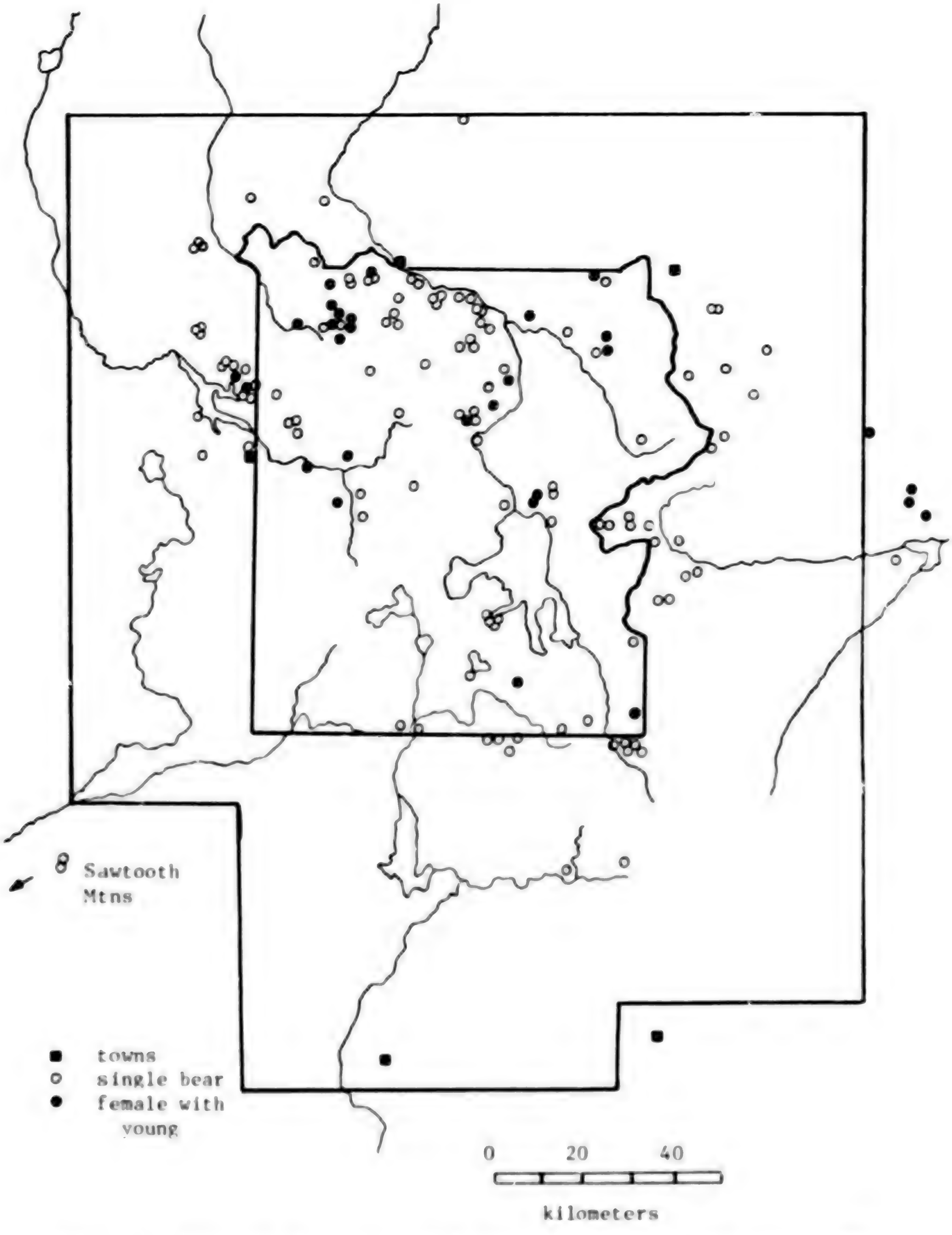

Fig. 7. Verified observations of unmarked grizzly bears during 1980.

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Table 3. Summary of aircraft flight reports, 1980

Month	Hours flown	No. flights	Bears obs.		Bears/flight		Bears/hr	
			Black	Griz	Black	Griz	Black	Griz
Jan	3	1	0	0	-	-	-	-
Feb	4	1	0	0	-	-	-	-
Mar	10	3	0	0	-	-	-	-
Apr	29	7	0	12	-	1.71	-	.41
May	42	8	7	20	.88	2.50	.17	.48
Jun	45	10	7	10	.70	1.00	.16	.22
Jul	78	14	3	38	.21	2.71	.04	.49
Aug	38	8	0	7	-	.88	-	.18
Sep	37	7	0	1	-	.14	-	.03
Oct	42	9	0	1	-	.11	-	.02
Nov	24	7	0	0	-	-	-	-
Dec	5	2	0	0	-	-	-	-
Total	357	77	17	89	.22	1.16	.05	.25

FOOD HABITS

PROCEDURES

. Yellowstone grizzly bear food habits were determined from scat analysis and ground investigation of feeding sites. Scats were collected whenever encountered during investigations of aerial relocations (relocation sites) of instrumented bears. The contents were assumed to be representative of the food habits of the bears in the study area.

All bear scats collected (grizzly, black, and species unknown) were included in the analysis. Dried scats were soaked in water to soften them and washed through two screens. Coarse material was retained in the large screen (holes 0.125 in.) and fine material, including seeds, was collected in the small screen (holes 0.0328 in.). All items were identified to species when possible, and the percent volume of each item was visually estimated.

Procedures used in the ground investigation of feeding sites are described by Blanchard (1980) and Knight et al. (in prep.). Because feeding activities produce evidence of varying observability and longevity, site examinations were not used alone to determine food habits. Site examinations provide data on habitat use and preference and feeding behavior which produces long lasting sign. Easily digestible food items which are rarely revealed through scat analysis (such as mushrooms) are often evident at the feeding site. The more digestible items are probably under-represented in scat contents and, therefore, in the food habits analysis.

To provide information on meat as a bear food, ungulate wintering areas in Yellowstone Park were searched for carcasses. The areas examined were Nez Perce and Rabbit Creeks, the Fountain Flats area, the Madison-Gibbon Rivers, lower Slough Creek and nearby Lamar River, and the Yellowstone River between Hellroaring Creek and the mouth of the Lamar River. When a carcass was located during a survey or relocation site examination, a mandible and femur were collected to determine the animal's age and physical condition at death. Carcasses were examined for evidence that the animal was killed and/or fed on by bears. The date of death and distance to timber or open were estimated.

RESULTS AND DISCUSSION

In 1980, 527 scats were collected and analyzed for content (Table 4). Fifty-two percent of the scats were deposited in summer (June-August) and 27% and 21% were deposited in spring (March-May) and fall (September-November), respectively.

Scats were grouped by season of deposition and major categories of scat contents (Table 5). Mammals, primarily elk *(Cervus canadensis)*, were the major food in spring despite the high digestibility of animal matter

Table 4. Bear scat content analysis, 1980 (N = 527)

Food item	No. scats	% Frequency occurrence	% Diet volume
Trees			
Pinus albicaulis (pine nuts)	99	18.8	14.0
Shrubs			
Amelanchier alnifolia	2	0.4	0.1
Arctostaphylos uva-ursi	1	0.2	0.0
Crataegus douglasii	1	0.2	0.0
Linnaea borealis	2	0.4	0.1
Purshia tridentata	2	0.4	0.0
Rhamnus alnifolia	5	1.0	0.5
Ribes spp.	1	0.2	0.0
Shepherdia canadensis	2	0.4	0.1
Vaccinium globulare	6	1.1	0.5
Vaccinium scoparium	22	4.2	1.4
Total	34	6.5	2.7
Sporophytes			
Equisetum fluviatile	2	0.4	0.1
Equisetum spp.	26	4.9	1.6
Moss (Bryophyte)	3	0.6	0.0
Mushroom	2	0.4	0.0
Puffballs	2	0.4	0.0
Total	35	6.6	1.7
Grasses and grass-like plants			
Agropyron spp.	2	0.4	0.2
Agrostis spp.	9	1.7	0.4
Bromus vulgaris	1	0.2	0.1
Bromus spp.	5	1.0	0.4
Calamagrostis spp.	9	1.7	0.5
Carex raynoldsii	1	0.2	0.1
Carex spp.	52	9.9	2.8
Elymus spp.	2	0.4	0.1
Festuca spp.	2	0.4	0.1
Grass	1	0.2	0.0
Grass/sedge	144	27.3	14.0
Juncus spp.	3	0.6	0.1
Melica spectabilis	1	0.2	0.0
Melica spp.	9	1.7	0.9
Muhlenbergia spp.	1	0.2	0.1
Phleum alpinum	8	1.5	0.5
Poa spp.	51	9.7	3.0
Scirpus spp.	2	0.4	0.1
Total	253	48.0	23.4

Table 4. Bear scat content analysis, 1980 (N = 527)
(continued)

Food item	No. scats	% Frequency occurrence	% Diet volume
Forbs			
Angelica spp.	1	0.2	0.0
Arabis spp.	1	0.2	0.0
Aster spp.	1	0.2	0.0
Cirsium scariosum	23	4.4	2.1
Cirsium spp.	5	1.0	0.3
Claytonia lanceolata	20	3.8	1.4
Claytonia spp.	11	2.1	0.6
Epilobium angustifolium	19	3.6	0.9
Epilobium spp.	10	1.9	0.7
Forb (unidentified)	18	3.4	0.8
Fragaria vesca	1	0.2	0.0
Fragaria virginiana	2	0.4	0.1
Fragaria vesca + virginiana	3	0.6	0.1
Fragaria spp.	3	0.6	0.1
Geranium spp.	1	0.1	0.1
Habenaria spp.	1	0.1	0.1
Hydrophyllum spp.	1	0.1	0.0
Liatris spp.	1	0.1	0.0
Liliaceae	1	0.2	0.0
Lomatium spp.	7	1.3	0.4
Melilotus spp.	1	0.2	0.0
Mertensia spp.	8	1.5	0.4
Orchidaceae	1	0.2	0.0
Perideridia gairdneri	33	6.3	2.8
Polygonum bistortoides	6	1.1	0.2
Polygonum spp.	5	1.0	0.3
Potomogeton spp.	3	0.6	0.0
Ranunculus spp.	4	0.8	0.1
Taraxacum ceratophorum	14	2.7	0.8
Taraxacum spp.	63	12.0	3.4
Tragapogon spp.	5	1.0	0.5
Trifolium repens	1	0.2	0.1
Trifolium spp.	40	7.6	2.2
Total	191	36.2	18.4
Mammals			
Beaver	1	0.2	0.1
Bison	16	3.0	0.5
Black bear	2	0.4	0.2
Cattle	1	0.2	0.1
Deer	5	1.0	0.5

Table 4. Bear scat content analysis, 1980 (N = 527) (continued)

Food item	No. scats	% Frequency occurrence	% Diet volume
Mammals (continued)			
Elk	107	20.3	17.0
Grizzly bear	5	1.0	0.5
Ground squirrel	1	0.2	0.1
Large mammal (unidentified)	21	4.0	2.7
Microtinae	1	0.2	0.1
Microtus spp.	5	1.0	0.3
Pocket gopher	7	1.3	0.6
Small mammal (unidentified)	1	0.2	0.1
Total	184	34.9	24.4
Insects			
Ants	135	25.6	4.0
Bees	2	0.4	0.0
Coleoptera	6	1.1	0.3
Grasshopper	13	2.5	1.1
Insect (unidentified)	1	0.2	0.0
Total	154	29.2	5.4
Fish, Cutthroat trout	3	0.6	0.1
Bird (unidentified)	1	0.2	0.0
Garbage	32	6.1	2.7
Miscellaneous			
Debris	100	19.0	6.5
Trap bait	8	1.5	0.8
Total	107	20.3	7.3

Table 5. Seasonal bear scat content analysis by major food categories, 1980

	SPRING[1/]			SUMMER[2/]			FALL[3/]		
	No. of scats	% Freq.	% Vol.	No. of scats	% Freq.	% Vol.	No. of scats	% Freq.	% Vol.
Trees	1	0.8	0.8	35	14.6	7.7	54	55.7	48.3
Shrubs	0	0.0	0.0	24	10.0	4.1	7	7.2	2.6
Grasses/sedges	38	30.2	20.4	145	60.4	27.5	21	21.7	8.3
Forbs	17	13.5	3.9	130	54.2	29.7	8	8.3	2.2
Mammals	105	83.3	71.7	25	10.4	5.4	45	46.4	23.1

1/ Spring = March, April, May
2/ Summer = June, July, August
3/ Fall = September, October, November

which tends to cause scat analyses to underestimate the importance of meat. Mammals occurred in 83% of the scats and made up 72% of the scat volume. When bears fed on meat, they apparently ate little else. The average volume of meat in all scats which contained meat was 86%. Grasses and sedges were the second most important foods in spring. The major summer foods were grasses, sedges, and forbs. Graminoids and forbs occurred in 60% and 54% of the scats, respectively, and made up 28% and 30% of the scat volume. Whitebark pine nuts *(Pinus albicaulis)* and mammals were the most important fall foods. Pine nuts occurred in 56% of the scats and made up 48% of the scat volume. Mammals occurred in 46% of the scats and made up 23% of the volume.

Thirty-one elk, four moose *(Alces alces)*, three bison *(Bison bison)*, and one sheep *(Ovis canadensis)* carcasses were found in 1980. Twenty-three of the 39 carcasses appeared to have been fed on by bears: 18 elk, 3 moose, and 2 bison. Three elk and two moose were killed by bears, but the causes of death for the remaining carcasses could not be determined. Of 23 carcasses for which the date of death was estimated, 16 died March-May, three died June-August, and four died September and October. Fifteen carcasses were female and 16 were male. All of the females died in March, April, and May while males died in every month, March-October. Forty percent of the carcasses were less than 2 years old (Table 6). Seven carcasses were in excellent condition at death, with femur marrow fat contents of approximately 90%. Two of these animals died in April and May, and five died in July, August, and October. Twenty-three carcasses were at a serious stage of malnutrition at death with marrow fat contents of less than 25% (Cheatum 1949). Twenty-two of these died in winter and spring. Seventeen carcasses were found in the open, 21 in the timber, and three at a forest-meadow edge. Sixty-eight percent of the carcasses found in the timber or open were less than 30 m from an edge.

Table 6. Age and sex of ungulate carcasses found in Yellowstone National Park in 1980

AGE:	1/2	1	2	3	4	5	6	7-11	Total
NO.:	7	7	2	2	3	0	4	10	35
SEX:	5F	4F	1F	1F	-	-	-	3F	14F
	-	1M	1M	1M	3M	-	4M	6M	16M

Ground examination of bear relocation sites detected feeding activities which left obvious and long lasting sign. The activities found most often were feeding on carcasses, digging for gophers and their caches, digging for roots and squirrel-cached pine cones, and tearing logs for insects (Table 7). When these feeding activities occurred frequently, scat content analysis usually showed a corresponding increase in the frequency of occurrence of the food item. Feeding on carcasses was one of the most common feeding activities found in spring. Carcasses were located at 47% of the sites. Carrion was the most important item in spring scats. It occurred in 83% of the scats. At another 47% of the sites examined in spring, bears had dug for pocket gophers *(Thomomys talpoides)*, but gophers and the contents of their caches appeared infrequently in scats. Torn logs were found at 41% of the sites in summer, and insects occurred in 41% of the summer scats. In fall, raided squirrel caches were found at 56% of the sites and pine nuts occurred in 56% of the fall scats.

Examination of bear relocation sites rarely detected grazing. Although grasses and sedges occurred in 48% of the scats and forbs occurred in 36%, evidence of grazing was found at only one site.

Table 7. Major feeding activities recorded at 1980 feed site exams

	Spring1/	Summer2/	Fall3/	1980
Carcass	17	3	6	26
Gopher dig	17	3	2	22
Root dig	4	6	1	11
Stripped bark	2	2	1	5
Unknown dig	2	1	1	4
Squirrel cache	0	3	15	18
Torn log	3	13	9	25
Turned rock	0	3	0	3
Torn anthill	4	4	0	8
Grazing	1	0	0	1
Other4/	2	2	1	5
No feeding	25	16	11	52
Total w/feeding activity	36	32	27	95
Total	61	48	38	147

1/ Spring = March, April, May
2/ Summer = June, July, August
3/ Fall = September, October, November
4/ Worms, insects, garbage

POPULATION PARAMETERS

FEMALES WITH YOUNG

From 1974 through 1980 the Interagency Grizzly Bear Team has monitored an average of 12 different females with cubs of the year. This has varied from a low of four during 1975 to a high of 17 during 1976 (Fig. 8). The total of nine different females monitored during 1980 was the lowest since 1975. Without a good population estimate, we cannot tell what percentage of the producing females we are monitoring. Percentages of radio-located grizzly bears actually observed from 1976 through 1980 indicate that aerial survey efficiency has been low. However, females with cubs are more observable than other segments of the population. While few or no females with cubs are seen during any single flight, a high percentage of them may be seen during the course of a field season. All radio-instrumented females with cubs have been observed at least once during each field season. Therefore, it is possible that the number of females with young monitored during any year is close to the total number in the study area.

Inspection of Figure 8 reveals a direct relationship between numbers of females that died during one breeding year and the total number monitored during the next breeding year. Female grizzly bears produce cubs approximately every 3 years. Looking at the numbers of females with cubs in the years 1974, 1977, and 1980, there is a decline in numbers of 15, 13, and 9, respectively. The decline from 15 in 1974 to 13 in 1977 corresponded with a mortality of five adult females in 1974. Also, the decline from 13 in 1977 to 9 in 1980 was matched by an adult female mortality of 5 in 1977. Information on the breeding status of females that died in 1974 is not available, but four of the females that died in 1977 had cubs of the year. This relationship between heavy female mortality and a decline in numbers the next time that population segment is observed also indicates close agreement between numbers of females with cubs monitored each year and the total within the study area. There was also a decline of three females and cubs between 1976 and 1979, although only one female mortality was recorded in 1976.

The only upward trend in numbers of females with cubs was from 1975 to 1978. The four females with cubs recorded in 1975 was the lowest observed during this study. This may have been related to a very poor year for observation, or a mortality of eight adult females in 1972, or a combination of both factors.

PRODUCTION

Age at First Pregnancy

The age at first pregnancy has been recorded for eight females; two of these first became pregnant at 4.5, three at 5.5, two at 6.5, and one at 7.5 years of age. The average age at first successful conception was 5.75 years of age. This was over 0.5 years older than the 5.2 years

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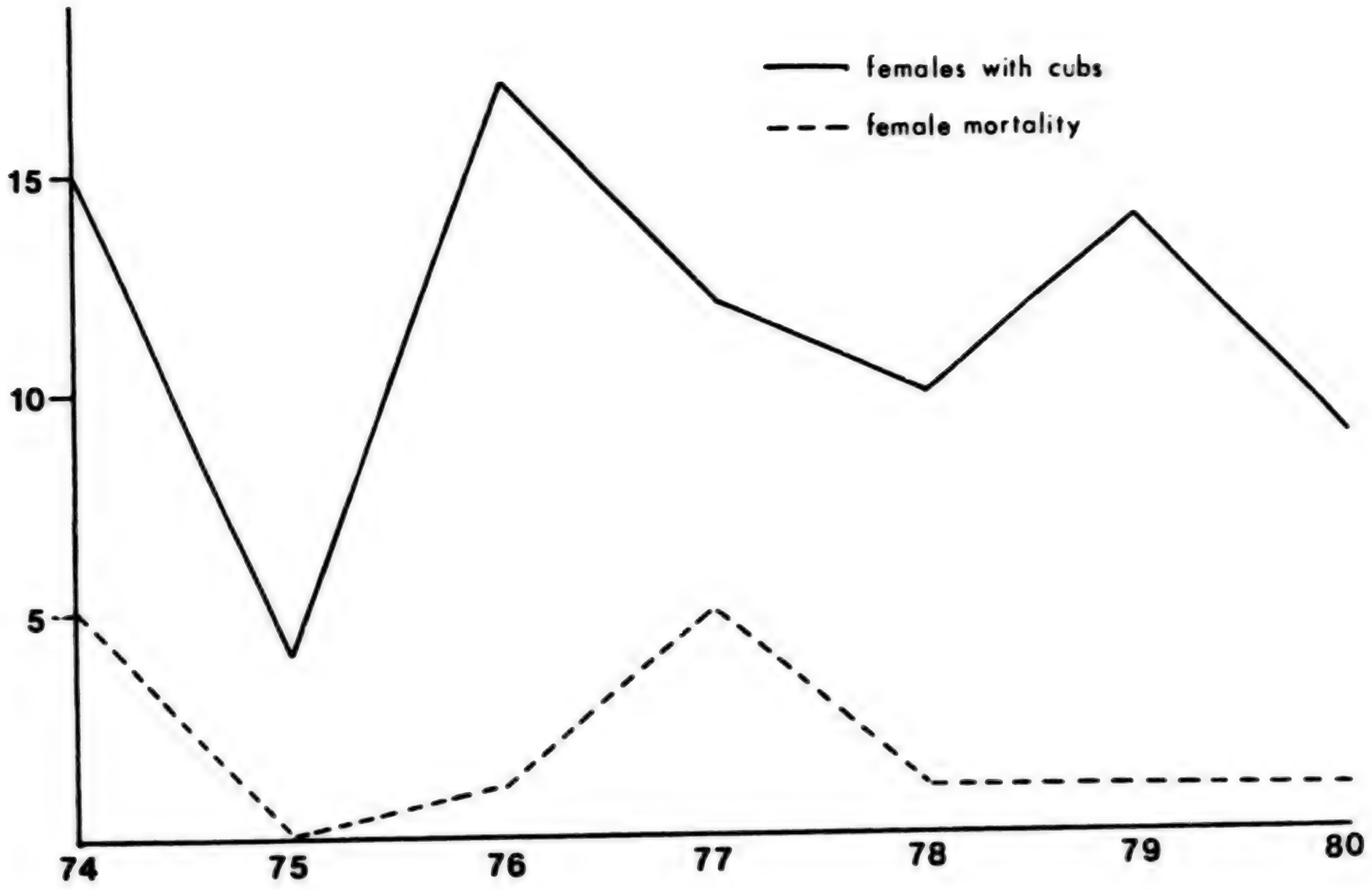

Fig. 8. Numbers of females with cubs observed and female mortalities, 1974-80.

recorded by Craighead et al. (1974) for 16 females bearing their first litter. Size of first litters ranged from one to three and averaged 1.75. The size of litters of marked females that were known or assumed to be second or later litters also ranged from one to three but averaged 1.86.

Female Reproductive Rate

The female reproductive rate is the number of young produced per breeding female per year. A mean for the population can be obtained by dividing the number of cubs produced by total reproductive years or dividing cubs produced each litter by number of years to the next litter and averaging. On an annual basis, reproductive rate can be estimated by dividing mean litter size by the mean reproductive cycle. Given an adequate sample, the results from all these methods should be the same.

Craighead et al. (1974) used reproductive histories of marked females to compute an average female reproductive rate of 0.668 for the period 1959-67. Their method was the most accurate but took a lot of time to get the data required for a sufficient sample size. Their cumulative sample included 68 reproductive cycles of 30 marked females.

By 1979 we had a sample size of seven reproductive cycles of six females to calculate a reproductive rate of 0.555. By 1980 we had a sample size of 10 cycles for eight marked females to calculate a reproductive rate of 0.810. This includes two females that lost or abandoned litters of one and rebred the same year, which resulted in abnormally shortened reproductive cycles. Recalculating the rate without the lost litters and shortened cycles, we have eight cycles for eight females and a reproductive rate of 0.680. This is considerably higher than that calculated in 1979 but still based on a very small sample. The calculated reproductive rate will probably fluctuate widely until an appreciably larger sample size is obtained. The true reproductive rate within the population will also fluctuate between years with variations in food availability.

Ratios of young:female for 1974 through 1980 are given in Table 8. Average annual litter size for 1980 was the largest recorded during this study. This probably reflects a year of high food abundance in 1979.

Sex and Age Structure

Since 1975, we have radio-instrumented 61 grizzly bears. An additional seven have been trapped, ear tagged, and released; and 19 cubs and yearlings have been associated with trapped females but not tagged. Twenty-five of these 87 bears are known to be dead, but 62 of them were believed to be alive during 1980. From these, we have constructed an age structure as illustrated in Figure 9.

Figure 9 indicates a very young age structure for an animal with as long a life span as the grizzly bear. Craighead et al. (1974) reported

Table 8 . Grizzly bear females with cubs, 1974-80

Year	Females	Cubs	Ratio
1974	21	36	1.7 cumulative sample
	15	26	1.7 unduplicated sample
1975	5	8	1.6
	4	6	1.5
1976	36	69	1.9
	17	35	2.0
1977	24	43	1.8
	13	25	1.9
1978	15	31	2.1
	10	19	1.9
1979	21	39	1.9
	13	26	2.0
1980	13	26	2.0
	9	19	2.1

longevity as 25.5 years. Our data indicate that few bears are reaching the older age classes. Most of the bears in the population studied by Craighead et al. are now gone although they should be well represented in the older age classes of the present population. Beecham (1980) has compared heavily and lightly hunted black bear populations in Idaho and found a preponderance of adult bears in the lightly hunted population and a 50:50 ratio of adults to subadults in the heavily hunted population. Our ratio of adults to subadults and cubs was 32:68. We are considering bears 5 years old and younger as subadults.

Sex ratios associated with the sample in Figure 9 were 62M:38F for adults and subadults. This might be explained by trapping bias but probably not. The sex ratio of 17 cubs handled in trapping operations since 1976 has been 71M:29F. The Yellowstone grizzly bear population appears to be characterized by a preponderance of males in all age classes.

From 1974 through 1979 we have sex and age information on 111 bears from either trapping or mortalities. These break down as 41% adults, 53% subadults, and 6% cubs. Sex ratios of these age classes were 54M:46F, 64M:36F, and 67M:33F, respectively. This does not show as high a discrepancy in the sex ratio of adult bears as indicated in the live only sample, but ratios remain essentially the same for younger bears.

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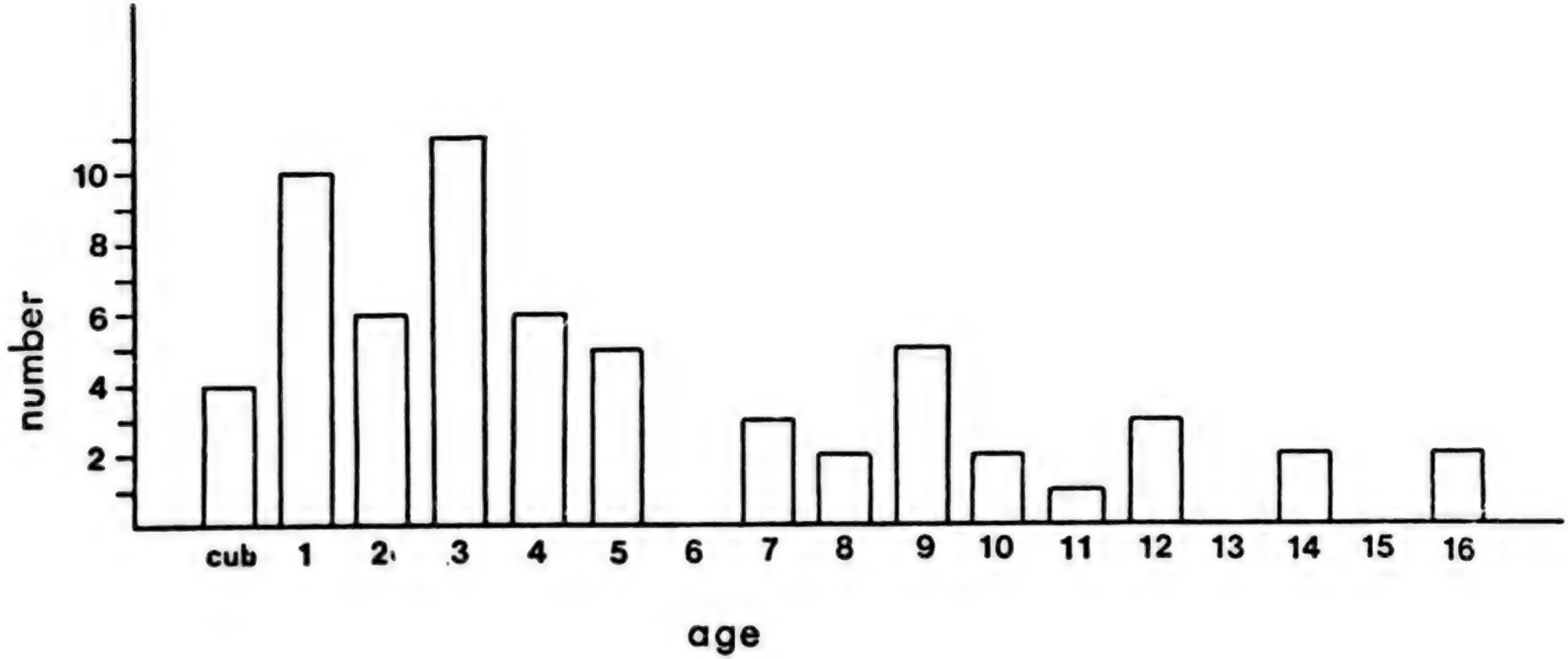


Fig. 9. Grizzly bear population age structure, 1980 (n = 62).

Considering a sample of only 52 dead bears for which we have sex and age information, sex ratios were 42M:58F for adults and 54M:46F for subadults. It is evident that females are being produced and recruited into the population at a lower rate than males and that they are dying at a higher rate than males.

Craighead et al. (1974) recorded a sex ratio of 59M:41F for 78 cubs from 1959 to 1970 but chose to attribute the imbalance to sampling procedures and used a 50:50 sex ratio for their population calculations. In light of our data which confirms their data on cub sex ratios and shows it carried through into the older age classes, we feel than an imbalanced sex ratio in favor of males must be accepted for the Yellowstone population and that management should proceed accordingly.

Mortality

There were seven known mortalities of grizzly bears during 1980. One adult male and one adult female were illegally killed by hunters. One adult male was killed by a truck. One yearling female was killed by another bear after injuring a foot in a snare, and one yearling female died of malnutrition. One 2-year-old male was killed after he had exhibited aggressive behavior in two campgrounds. He was in a state of malnutrition when he was killed. One cub associated with a marked female was lost or abandoned in early summer.

POPULATION ESTIMATION

Using estimated sex and age ratios with a segment of the population for which we have the most confident estimate of numbers, we were able to make a point estimate of the population size. We chose adult females as the segment for which we had the best information. During 1978, 1979 and 1980 we observed 10, 14 and 9 females with cubs, respectively. During this time, three of these have died leaving at least 30 adult females in the population, assuming a breeding interval of about 3 years. We also assumed, for the purpose of this estimate, that any unknown natural mortality was compensated for by recruitment.

We realized that if our estimated breeding interval of 2.17 was representative of the population, there would be fewer adult females. Also, the sex and age data indicate that recruitment of females does not compensate for mortality.

Using 30 adult females as a basis for calculation and applying the observed adult sex ratio of 62M:38F, we can estimate that we have 49 adult males in the population. This gives us a total of 79 adults. Using the observed ratio of adults to subadults of 32:68 we can estimate a total of 168 subadults. This gives us a total of 247 bears in the population.

We wish to emphasize that this is a point estimate based on some small sample sizes and we are unable to assess its precision of accuracy at this time.

PHYSICAL CHARACTERISTICS OF YELLOWSTONE GRIZZLY BEARS

Seventy grizzly bears were trapped 113 times from 1975 through 1980. Measurements of various physical characteristics were taken while the bears were being marked (Fig. 10). Body weights were estimated and measured when possible.

BODY WEIGHT

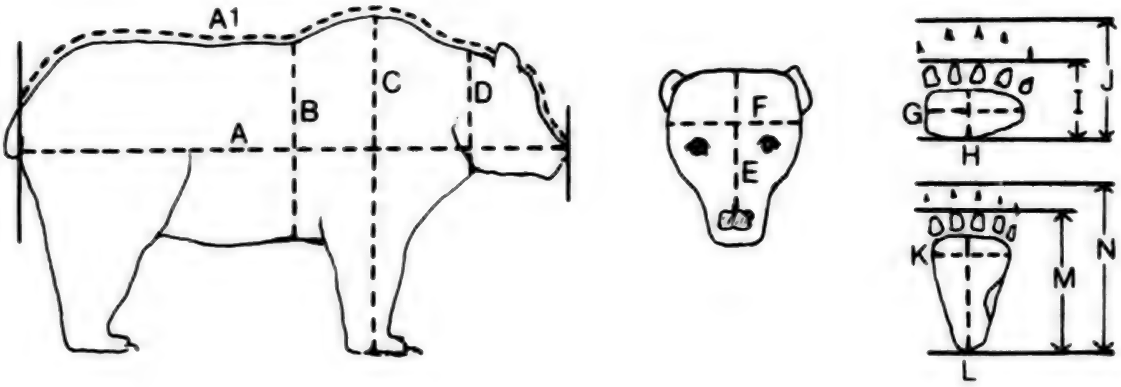
Body weights varied greatly depending on sex and age of the animal, and the time of year the measurement was taken. Mean weights between males and females of the same age class were not different until the 6-year age class ($t = 2.31$, $df = 4$, $P < 0.1$), as shown in Figure 11. The difference became highly significant in the 7+ year age class ($t = 5.91$, $df = 42$, $P < 0.001$). Means and extremes of body weight within age classes are shown in Table 9.

Annual weight gains from cub through subadult age classes are as follow: cub to yearling, 55%; yearling to 2-year-old, 34%; 2-year-old to 3-year-old, 16%; and 3-year-old to 4-year-old, 7%. Yearly weight increases did not differ significantly between males and females until the 3-year age class when males began gaining more weight per year than females. Females appear to level off in weight gain at 4 to 5 years of age, while males continue to gain weight beyond 7 years of age (Fig. 11). Kingsley, Nagy, and Russel (1980) found that male grizzly bears in northern Canada also take longer to reach mature weight than females.

The mean weight of grizzly bears trapped during the spring was usually less than the weight of those trapped during the fall. Mean spring-to-fall weights of seven yearlings increased by 32%; weights of seven 4-year-olds increased by 22%. The mean spring weight of 11 adult (7+ years) males increased 23% by fall, while mean spring weight of seven adult females increased by only 5%.

Limited data support the theory that bears with supplementary food sources may be in better physical condition than bears using only natural foods (Russel et al. 1979). The Cooke City garbage dump was closed in 1980, and grizzlies did not obtain any food at the dump that year. Three adult grizzly bears known to frequent that dump since 1975 were recaptured in 1980. All three weighed less than during previous years. Mean weights of bears using the dump and bears with no dump available were significantly different for males 5 years and older ($t = 2.14$, $df = 23$, $P < 0.05$). There was no significant difference between mean weights of females.

The largest grizzly bear marked during this study was trapped during mid-summer in the Cooke City dump. This 16-year-old male (Bear No. 9) weighed 325 kg (715 lb.), which was 126 kg (277 lb.) heavier than the mean weight of adult males using only natural foods. The largest adult male known not to use a garbage dump (Bear No. 1) weighed approximately



A	total length
A1	contour length
B	girth
C	height at shoulder
D	neck circumference
E	head length
F	head width

Fore foot:	G	width
	H	length of pad
	I	length to toe-tip
	J	length to claw-tip
Hind foot:	K	width
	L	length of pad
	M	length to toe-tip
	N	length to claw-tip

Fig. 10. Physical measurements diagram.

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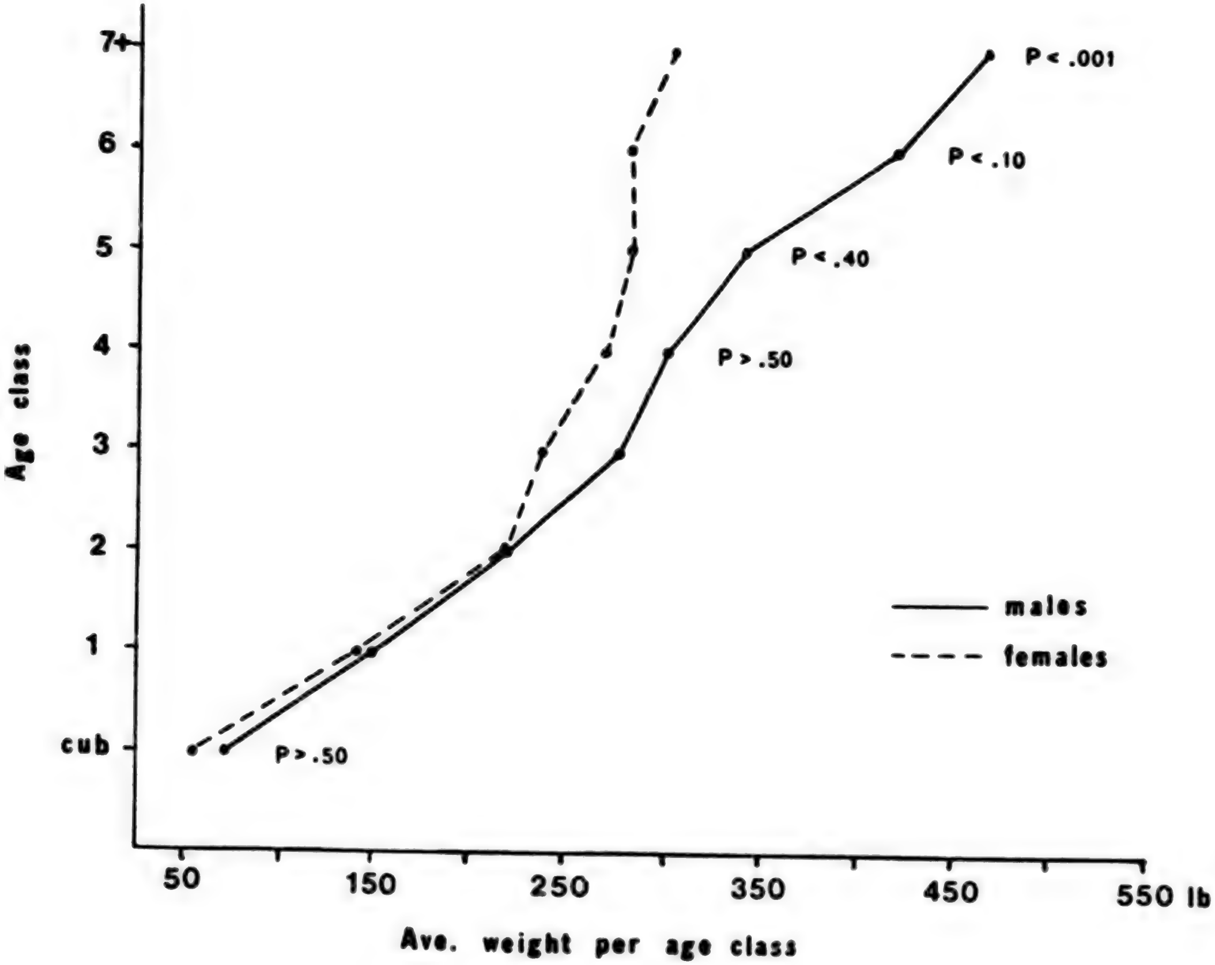

Fig. 11. Comparison of average weights by age class between male and female grizzly bears (T-test).

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Table 9. Body weight (kg) within age classes of grizzly bears

	Age class							
	Cub(9)*	1(13)	2(13)	3(6)	4(11)	5(8)	6(6)	7+(44)
Minimum weight	15.9	25.0	68.0	95.3	90.7	102.1	127.0	102.1
Maximum weight	52.2	113.4	124.7	158.8	179.2	181.4	219.5	324.3
Mean weight	29.9	66.2	100.2	119.3	128.8	140.6	134.3	181.0

* Sample size.

272 kg (600 lb.) in September 1978. However, he was known to supplement his food supply with domestic livestock.

BODY MEASUREMENTS

Mean measurements of males and females within age classes are shown in Table 10. There were no significant differences between males and females until the 4-year age class. At this age, width and length of hind foot pad and length of front foot pad to claw tips became significantly different (width: $t = 3.00$, $df = 7$, $P < 0.025$, length: $t = 3.79$, $df = 7$, $P < 0.01$); front: $t = 4.08$, $df = 7$, $P < 0.005$). In the adult age class (7+ years) length of head, width of head, neck circumference, length and width of front foot pad, and length and width of hind foot pad were very different ($P < 0.025$) between males and females. Other different mean measurements between sexes in this age class were girth and height at shoulder ($P < 0.2$).

The size of a grizzly bear cannot be consistently predicted from a foot pad measurement. A linear regression between front foot pad width and height at shoulder had a coefficient of correlation equal to 0.55 ($n = 75$).

COLOR PATTERNS

Coat colors of Yellowstone grizzly bears vary greatly. Lighter tipped guard hairs give different color patterns and tones, depending on light intensity. Colors also change as the bears shed and as they mature. Five major color patterns have been observed during this study (Table 11).

The most frequently observed grizzly in the Yellowstone area has medium to dark brown underfur; brown legs, hump, and underparts; light to

Table 10. Mean body measurements of grizzly bears.

Age	Sex(n)	A[1]	A-1	B	C	D	E	F	G	H	I	J	K	L	M	N	Wt
Cub	M (6)	91cm	109cm	76cm	57cm	45cm	27cm	15cm	82mm	63mm	92mm	124mm	83mm	119mm	156mm	171mm	33kg
	F (3)	89	112	64	49	38	26	16	88	43	85	112	80	110	144	160	25
1	M (8)	136	171	95	71	54	33	18	114	59	107	146	105	146	191	214	68
	F (5)	108	136	90	64	53	31	16	102	51	101	140	97	139	180	195	64
2	M (9)	129	155	102	80	63	39	22	123	61	112	159	136	165	210	233	101
	F (4)	126	157	101	82	59	36	22	119	61	116	152	120	155	199	215	99
3	M (4)	169	184	110	86	65	39	23	137	69	120	168	122	183	225	246	125
	F (2)	133	164	106	85	60	36	20	117	61	112	153	107	159	205	221	108
4	M (6)	160	180	114	95	68	39	22	135	65	123	167	128	178	221	245	135
	F (5)	128	176	109	88	68	37	20	126	68	113	144	109	163	209	228	121
5	M (4)	158	222	118	91	62	39	22	133	75	129	174	128	188	238	257	154
	F (4)	166	159	109	82	65	38	20	117	65	113	152	110	158	198	218	127
6	M (5)	186	191	144	91	83	42	26	147	79	129	181	133	180	237	260	190
	F (1)	133	181	111	-	63	39	29	129	57	110	165	110	175	215	230	127
7+	M(26)	172	192	132	94	77	41	28	150	75	135	175	140	191	239	258	186
	F(18)	161	180	124	89	65	36	23	130	67	120	156	121	155	209	225	127

[1] Defined in Fig. 10.

Table 11. Color patterns of grizzly bears trapped from 1975 through 1980

Girth band		Gold/silver		Black		Medium		Multicolored	
Bear	Age	Bear	Age	Bear	Age	Bear	Age	Bear	Age
1	16	3	7	7	4	2	4	48	2
5	12	20	4	10	9	4	4	27	1
8	14	25	5	43	2	6	8	49	2
9	16	32	2	57	Ad	13	8	52	1
11	7	39	3	35	5	26	13	53	1
12	11	44	Ad	5 Total		28	16	54	1
15	9	G-2	2			34	6	59	SAd
17	2	G-3	Cub			36	10	60	2
19	7	G-4	Cub			42	8	8 Total	
21	6	9 Total				45	Cub		
22	8					47	1		
23	1					G-1	1		
24	2					G-7	Cub		
31	Cub					G-10	2		
33	3					14 Total			
37	Cub								
38	9								
40	5								
41	2								
46	SAd								
50	Ad								
51	Ad								
55	1								
56	1								
58	2								
61	Ad								
G-9	Cub								
G-11	Cub								
28 Total									

medium grizzling on the head and part of the back; and a light-colored girth band or patch behind the forelegs. Three other color patterns are commonly observed: bears with an overall gold or silver appearance and brown underparts and occasionally a dark back stripe; bears with no distinct silver tipping, giving a black or brown appearance; and bears with medium to dark brown underfur, rump, legs, and hump and medium to heavily grizzled forequarters and face.

Subadult grizzlies often appear multicolored, with various shadings of red, blond, and brown underfur and great variations in amount of silver tipping. Light-colored "yolks" on the chest and dark back stripes are common. These color patterns gradually fade as the bears age, and one of the four previous patterns is usually present at maturity.

IMMOBILIZATION OF GRIZZLY BEARS

METHODS

Grizzly bears were immobilized 114 times from 1975 through 1980. Sernylan (phencyclidine hydrochloride) and M-99 (etorphine) were used as immobilizing drugs. Acepromazine (acetylpromazine) was often used as a tranquilizer with Sernylan.

A CO_2-powered "cap-chur" pistol and dart, a 32-gauge long range capture rifle, or a syringe mounted on a "jab-stick" was used to inject drugs intramuscularly. Additional dosages were injected with a hand-held syringe.

RESULTS

Sernylan was used 87 times to immobilize grizzlies. Bears' wide tolerance latitude for Sernylan and the ability to give multiple doses make it nearly impossible to fatally overdose animals (Skjonsberg and Westhaver 1978). The tranquilizer, Acepromazine, was often used with Sernylan since it has a calming effect and lessens side effects of Sernylan, such as convulsions. It also decreases the time to immobility and in some cases the amount of Sernylan needed.

Sernylan has been administered at an average rate of 0.99 mg per pound of body weight (Table 12). Dosages ranged from 0.64 to 1.78 mg/lb. Increased dosages are frequently necessary in the fall when thicker fat deposits must be penetrated. Thirty bears captured from March through June were immobilized with an average of 0.90 mg/lb, while 20 fall (September-November) captures required an average of 1.17 mg/lb.

The average time from first injection to immobilization was 20 minutes (n = 56). When additional dosages were required to obtain immobilization, this time was increased to 36 minutes (n = 26).

Complete recovery occurred an average of 210 minutes following first injection (n = 57), with a range of 53 to 415 minutes. The average time from first injection to first leg movement was 106 minutes (n = 68).

No bears were fatally overdosed with Sernylan. Two grizzlies died when darts punctured internal organs.

M-99 was used 27 times to immobilize grizzly bears. This drug has been used when a situation requires immediate arousal of the animal after handling. This drug is used with caution since an immobilized animal may suddenly become alert without an antidote injection (M-50/50).

Grizzlies were immobilized with an average dose of 0.93 mg per 100 pounds of body weight (Table 13). Dosages ranged from 0.52 to 1.86 mg/100 lbs. The average time from injection to immobilization was 24 minutes (n = 25) and ranged from 9 to 60 minutes.

Table 12. Dosages of Sernylan used to immobilize grizzly bears

Bear No.	Sex	Age	Wt1/	Dosage (mg)	Minutes to immobilization	Min. to 1st reac.	Min. to recovery
1	M	11	320	140	53	86	89
		12	375*	500	52	175	208
		13	600	825	206	22	-
		16	430	350	13	-	184
2	M	4	270	275	7	27	-
3	F	5	290*	200	29	67	132
		7	285*	350	10	284	359
4	F	3	210	220	8	49	206
		4	350	350	58	75	115
5	M	12	390	390	54	75	90
		12	450	360	14	102	-
6	F	4	225	200	58	49	104
		4	215	200	-	41	81
		5	225	250	69	54	135
		8	250	300	5	-	-
8	F	14	230	200	10	155	325
10	F	9	310	390	12	168	308
11	M	6	468*	350	33	-	-
		7	450*	300	11	109	354
12	F	8	275	250	25	50	-
		8	275	250	28	-	-
		11	425	350	12	-	-
14	M	9	500	750	25	215	-
15	M	6	400	385	14	-	-
		7	475	385	10	200	380
		9	350	300	12	228	348
17	M	2	200	200	5	35	-
19	M	7	350	260	10	72	132
20	M	4	250	275	17	110	245
21	F	4	200*	130	10	65	220
		4	210*	275	8	-	-
		6	280*	230	22	75	145
22	M	5	250	250	55	62	182
		8	385	550	44	47	87
23	F	1	250	250	8	225	315
24	F	2	200	350	5	39	184

Table 12. Dosages of Sernylan used to immobilize grizzly bears (continued)

Bear No.	Sex	Age	Wt1/	Dosage (mg)	Minutes to immobilization	Min. to 1st reac.	Min. to recovery
25	F	5	250	350	20	-	-
26	F	13	400	475	35	-	-
28	F	16	225	400	10	87	317
31	M	Cub	42*	55	37	45	118
32	M	2	230*	200	30	70	-
33	M	3	350	300	10	191	244
34	M	6	370	300	7	170	390
35	M	3	225	160	15	47	177
		4	300	275	39	35	140
		5	325	480	95	240	335
36	M	10	450	300	9	53	-
37	M	Cub	40	40	8	179	329
		1	110	150	60	53	108
38	F	7	300	375	37	98	278
		8	400	430	-	290	-
		9	400	350	11	194	320
40	M	4	275	360	40	100	415
41	M	1	120	95	11	92	247
		2	200	175	7	222	222
42	M	8	360*	300	12	-	-
43	F	2	270*	400	62	220	-
		3	265	225	12	-	-
44	M	Ad	450	490	20	90	-
45	M	Cub	110*	80	-	-	-
46	M	SAd	300	460	41	182	-
47	F	1	145	200	27	-	-
48	F	2	225	180	10	126	171
49	M	2	225	200	17	140	235
		2	220	200	15	58	-
		2	250	250	40	45	-
50	F	Ad	275	275	8	-	169
51	M	13	550	350	28	135	285

Table 12. Dosages of Sernylan used to immobilize grizzly bears (continued)

Bear No.	Sex	Age	Wt 1/	Dosage (mg)	Minutes to immobilization	Min. to 1st reac.	Min. to recovery
52	M	1	130	100	10	163	223
53	F	1	110	80	8	55	70
54	M	1	120	80	11	77	149
55	M	1	170	116	78	47	167
56	F	1	150	130	5	131	153
57	M	9	600	500	9	-	240
59	F	2	175	225	19	-	-
60	F	2	170	180	15	73	133
		2	180	140	12	18	93
61	M	4	535	400	4	-	271
G-1	F	1	55	50	5	41	105
G-2	M	2	150	125	19	80	135
G-3	F	Cub	68*	60	5	22	307
G-4	F	Cub	63*	50	7	125	-
G-7	M	Cub	50	35	9	23	53
G-8	M	Cub	75	90	-	-	-
G-9	M	Cub	75	90	-	-	-
G-10	M	2	275	225	18	173	205
G-11	F	Cub	37	40	21	52	242

1/ Weight in pounds; * indicates scale weight.

Table 13. Dosages of M-99 used to immobilize grizzly bears

Bear No.	Sex	Age	Wt[1]	Dosage (mg)	Minutes to immobilization
5	M	7	360*	2.5	20
		8	400	3.0	17
		9	505*	4.0	20
7	M	4	300*	3.0	15
8	F	9	250	2.0	15
		11	300*	2.2	30
9	M	14	610*	5.0	15
		15	665*	6.0	30
		16	715*	7.0	25
10	F	4	350*	4.0	30
		5	355*	4.0	20
13	F	7	255*	2.0	30
		8	265*	2.0	25
15	M	5	385*	2.0	27
		6	375*	4.0	25
		6	484*	4.0	30
		8	350*	6.5	60
16	F	10	255*	3.0	20
		11	318*	3.0	10
18	M	3	305*	4.0	35
20	M	4	395*	4.0	20
27	M	1	215*	1.8	30
30	M	1	218*	2.0	30
39	M	3	225*	1.6	-
40	M	5	400	4.0	9
58	M	2	250	2.5	15
G-5	M	1	125*	0.75	-

[1] Weight in pounds; * indicates scale weight.

AN EXPANDABLE RADIO COLLAR FOR YOUNG BEARS

The Interagency Grizzly Bear Study (IGBS) has been live-capturing and radio-collaring grizzly bears *(Ursus arctos)* since 1975. Cubs-of-the-year and small yearlings were not instrumented because the collars did not allow for rapid neck growth. For this reason the fate of lost, abandoned, and weaned young was rarely known. The survival of young is an important factor in determining population status and trend (Blanchard and Knight 1980). The only method to effectively gather reproductive data on dispersed bear populations is radio telemetry, thus necessitating the development of expandable radio collars for young bears.

Other researchers have developed expandable radio collars for domestic sheep and ungulates (Kolz and Johnson 1980) and foxes (Follmann and Bruitt 1978). These collars have not been compatible with the life style and behavior of bears.

COLLAR CONSTRUCTION

A Telonics transmitter was pop-riveted between two sections of two-ply conveyor belting (Fig. 12). Each belting section was approximately 80 cm long and 5 cm wide. The transmitter antenna was shortened to eliminate overlap at the final collar closing site and secured between paired steel pop rivets approximately 8 cm apart. The antenna is thereby protected between two layers of belting passing over the back of the animal's neck.

Flexible uralane plastic (Con-Ap) was poured around the radio transmitter to a minimum depth of 5 mm on each side of the transmitter (Fig. 9). A molding of aluminum strips, duct tape, and caulking was used to contain the liquid plastic until dry. The uralane was oven-cured at 48-52° C for 6 hours.

A slip-loop of 3-cm-wide belting was riveted around the collar on each side of the transmitter (Fig. 9). A nylon-covered elastic shock cord (6-10 mm diameter) was attached to the belting loop on the side of the antenna attachment. The cord was attached with a steel pig ring. The cord was then passed along the outer collar surface and through the other belting loop without stretching the cord.

A loop was made in the free end of the cord and fastened with a steel pig ring. The final attachment of the collar on a bear involved placing the free looped end of the cord between the two layers of belting passing over the animal's neck, and securing with a bolt or rivet through both layers of belting and the center of the cord loop. The collar can be adjusted to comfortably fit the bear and yet will allow for neck expansion as the cord stretches.

To keep the cord and belting loops in position and provide additional protection to the antenna and cord, we wrapped the entire collar with

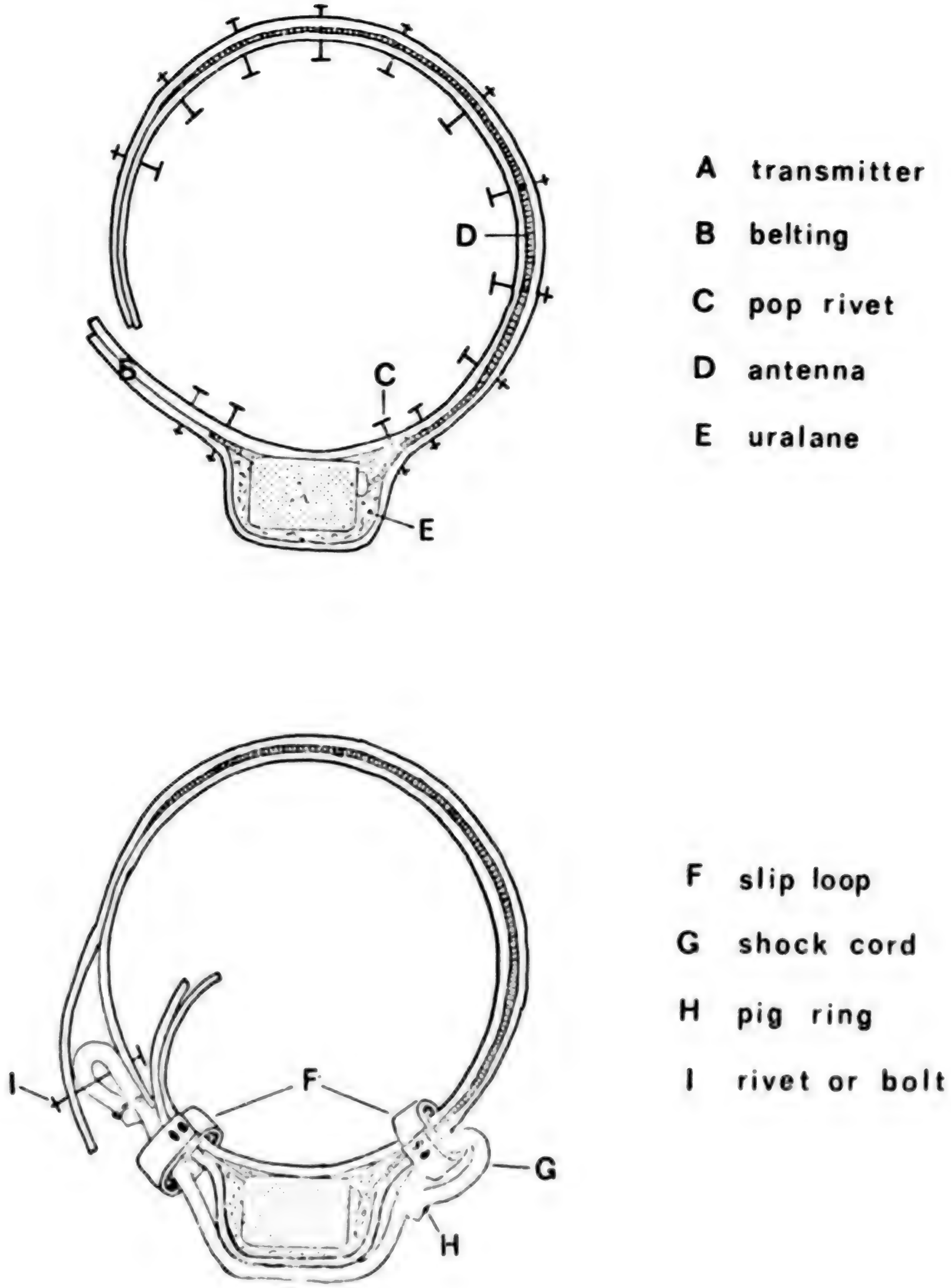

Fig. 12. Construction of an expandable radio collar.

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electrical tape, beginning at the outer belting loop and ending at the last rivet past the end of the antenna. This also prevented rivets on the collar inner surface from snagging hair. The section of shock cord between belting loops was wrapped with light-weight plastic before applying the tape. This allowed the cord to stretch freely under the tape layer.

RESULTS

From 1977 through 1980, 10 male and 2 female grizzly bears were equipped with adjustable radio collars (Table 14). A 40-pound (18 kg) male cub was fitted with one of these collars on August 22, 1978. His movements were monitored until September 22, 1979, when he was recaptured and fitted with a standard adult collar. The adjustable collar was in good condition although the shock cord was nearly fully stretched and beginning to show signs of deterioration. The yearling's neck showed no signs of abrasion or evidence that the collar was too tight. He weighed 130 pounds (59 kg), a 325-percent weight gain, and his neck circumference had increased from 40 to 51 cm.

Seven of the 12 bears wore their collars for 4 months or less. One of these bears was killed, four cast their collars, one was retrapped and the collar was removed, and one transmitter failed.

The remaining five bears wore their collars for at least 7 months. One of these bears was killed, one cast its collar, and three were still wearing their collars as of December 1980.

The cast collars were apparently easily slipped over the head by the bear. The success of these adjustable collars appears to be limited by a bear's willingness to wear the collar and his chances of survival. Maximum life expectancy for these collars is approximately 1 year. The shock cords begin to deteriorate after this time. Natural deterioration of the collar is necessary for subsequent release when a bear cannot be recaptured and fitted with a larger collar.

Transmitter signal strength appears to be diminished with the smaller animals and is probably due to the shortened antenna and the reduced distance between transmitter and ground.

Table 14. Young grizzly bears fitted with expandable radio collars

Bear No.	Age	Wt. (kg)	Period monitored	Result
27	1	98	09-13-77 to 05-26-78	Killed; collar intact
29	1	34	07-15-77 to 10-12-77	Killed; collar intact
30	1	99	09-21-77 to 06-14-78	Collar cast; not found
31	Cub	19	09-22-77 to 10-21-77	Collar cast intact
37	Cub	18	08-22-78 to 09-22-79	Recaptured; collar intact
41	1	55	05-08-79 to 08-10-79	Collar cast intact
45	Cub	50	10-04-79 to 11-30-79	Collar cast intact
49	2	100	07-26-80 to Dec. 80	Collar still on
52	1	59	06-05-80 to Dec. 80	Collar still on
53	1	50	06-06-80 to Dec. 80	Collar still on
54	1	55	06-10-80 to 10-07-80	Collar cast intact
55	1	57	06-11-80 to Oct. 80	Transmitter failure

RECOMMENDATIONS AND CONCLUSIONS

Population data indicate the Yellowstone grizzly bear population is "walking on a tight-rope" and has the potential to slide into a declining trend if careful and sincere efforts are not made by management agencies. Mortality and habitat loss directly affect population size and stability, and are the only factors we can directly alter. If implemented, the following recommendations may preserve the grizzly as a viable, self-sustaining member of the ecosystem.

MORTALITY

Every reasonable effort must be made to decrease the number of grizzly bear deaths to zero. Female and subadult survival is critical at this time. If proper control over bear/people conflicts cannot be maintained without the legal aid of the Endangered Species Act, the grizzly bear should be listed as endangered.

Known controllable sources of mortality are as follows:

1. Garbage dumps
2. Livestock allotments
3. Unsanitary camps, campgrounds, and private homes
4. Commercial developments (subdivisions, businesses which handle food, etc.)
5. Areas of high density human use
6. Unrestricted vehicular use
7. Professional poachers
8. Improperly placed trails and campgrounds
9. Improperly implemented logging and mining activities

Recommendations to reduce mortality are as follows:

1. Eliminate sheep grazing within grizzly bear range.
2. Eliminate garbage dumps and unsanitary conditions in camps, campgrounds, and around private homes which may attract bears.
3. Secondary roads within grizzly bear range must be closed to public use when bears may be using the area.
4. Discourage developments causing increased density of human activity within grizzly bear range.
5. Limit density of human use within grizzly bear range. Certain areas may need to be closed to human use seasonally or permanently.
6. State and Federal law enforcement regarding illegal mortalities must be prompt and effective.
7. Trails and campgrounds must not be placed in areas commonly used by grizzlies.

HABITAT LOSS

Certain areas must be set aside where grizzly bears are given priority over all conflicting land uses. These areas must be contiguous. Data indicate grizzly bears consistently use large areas with a diversified vegetational complex and good timber cover. Man-caused habitat loss may be sudden or cumulative. It is important that grizzly bear habitat be managed as one unit with a long range plan to guard against cumulative "small" habitat losses.

Known sources of habitat loss are as follows:

1. Logging, timber salvage, and associated timber management practices.
2. Energy-related activities (oil and gas exploration, mining, geothermal development).
3. Livestock allotments and range utilization
4. Disease and insect infestations resulting in local or widespread reduction in the density of whitebark pine.

Recommendations to alleviate deleterious effects of habitat alteration are as follows:

1. Open areas should be no greater than 300 m wide.
2. Increase as much as possible the timber-to-opening edges.
3. Strips of timber at least 100 m wide should be left between clearings.
4. Timber canopy (over 3 m tall) must have a canopy cover greater than 5 percent.
5. Restock depleted whitebark pine stands and introduce new stands in suitable habitat.
6. Eliminate or reduce livestock grazing on ungulate range within grizzly bear habitat.

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OF THE
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Appendix A

1980 WORK PLAN

At the 1979 meeting of the Steering Committee, it was agreed that future work plans would largely reflect research needs called for in the recovery plan. Although the recovery plan is well underway, it will probably not be completed until late summer. The following work plan reflects the needs of the recovery plan as we now understand it.

I. Major Objectives

A. Population parameters

1. Reproductive rates
2. Cub and yearling survival rates
3. Recruitment
4. Mortality

Techniques and procedures will involve instrumenting bears with radio transmitters. Emphasis will be placed on instrumenting females and subadults. New developments in radio-telemetry will allow us to instrument cubs and yearlings. Adult males will be tagged with colored ear tags but only occasionally instrumented. Fewer radio-tracking flights will be required since movements of instrumented bears will be studied mainly on a monitoring level. More emphasis will be placed on observation flights to obtain population parameter data.

B. Habitat use

1. Early spring and late fall use
2. Effects of wildfire
3. Habitat preferences

We now have nearly adequate data on general habitat use and food habits of Yellowstone grizzly bears. Additional data is needed during the early spring and late fall.

During the summer of 1979, a 5,000-acre wildfire occurred within the range of a bear we have been monitoring for 3 years. A special effort will be made to detect any changes in this bear's use of the area over the next several years.

Habitat preference and selection will be investigated through comparison of the plant community composition of areas with differing intensities of bear use.

C. Behavior

1. Daily activity patterns
2. Aggression

Daily activity periods of grizzlies will be determined by monitoring bears instrumented with motion-sensing transmitters for continuous 24-hour periods. The response of grizzlies to human activity, weather, and other animals will also be recorded.

Aggression of grizzlies toward humans will be studied by determining flight distance for individual grizzlies, both marked and unmarked; and by determining adrenaline level differences of individual trapped animals from urine catecholamine levels. Possible relations among flight distances, adrenaline levels, and coat color will be investigated.

II. Minor Objectives

A. Distribution - monitoring

B. Movements - monitoring

C. Food habits and habitat use

1. Spring ungulate use
2. Riparian habitat classification
3. Community analysis of use sites
4. Scat collection and analysis
5. Ant species collection and identification
6. Plant food collection and succulence determination
7. Whitebark pine production - monitoring

The distribution and movements of Yellowstone grizzly bears have been largely determined and will be studied on a monitoring and updating basis.

Several aspects of food habits and habitat use will be studied to supplement areas in which data is insufficient. Emphasis will be placed on obtaining spring and fall information, including spring use of ungulates as a food source.

A graduate student will be working on a riparian habitat classification.

Scats will be collected throughout the year and analyzed. Ant species utilized as food will be collected and identified. Plant parts eaten will be sampled and analyzed for moisture content. Whitebark pine cone production throughout the study area will be monitored. Plant community analysis of bear use sites will be conducted at randomly selected bear locations with emphasis on spring and fall seasons.

END

9-10-82